BATTERY OF TWO 6-INCH COAST DEFENSE RIFLES, MOUNTED UPON DISAPPEARING CARRIAGES.
(Constructed by the Author at the U. S. Military Academy at West Point, 1907.)

MILITARY PREPAREDNESS
AND
THE ENGINEER

BY

ERNEST F. ROBINSON, Assoc. M. Am. Soc. C. E.

Captain, Corps of Engineers, N. G. N. Y.

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AUTHOR'S PREFACE.

The purpose of this book is to place before the Engineers of America as accurate an idea as possible of the opportunities and limitations that will confront the Civilian Engineer in the event of war, to show him what he can do to assist in preparedness against invasion and how he must go about the matter.

Modern War is largely an engineering problem, and for its successful conduct there must be at the service of the country from the first a very large number of engineers with more than an indefinite notion that they are willing to fight, and die if need be, for their country. Many, many more will fight and fewer by far will die, if the engineering profession at large can readily obtain a proper conception of the duties, the responsibilities, and the active functions of the individual engineer, in a few weeks immediately following his call to the colors.

For this reason the Author addressed several large meetings of Engineers belonging to the American Society of Civil Engineers, the Harvard Engineering Society of New York, etc., and what he was able to present on the platform and the screen was so enthusiastically received that he was very ready to acquiesce in the invitation of the Publishers to give the material to the profession at large by broad publication.

The material of the lectures has been carefully revised and very materially enlarged. The book, however, is not a service manual, of which several, admirably prepared by the War Department, are available. It attempts only to fulfill the purpose originally indicated. If this attempt be successful, the Author's obligations and his hopes will have been more than met.

A large part of the technical matter is based upon the

Engineer Field Manual, U. S. Army, and a number of cuts have also been reproduced from the same source. Chapter VI, "Engineer Troops in the Field," is taken almost entirely from an article in the Official Bulletin, General Staff, Vol. 1, No. 4, Dec., 1914. The matter was so important, as giving specifically and in detail the duties of the Engineers under all conditions, that nearly half the original article is here reproduced.

The matter in Chapter V, on rifle instruction, illustrates the methods devised and used by the Author in his own company.

Acknowledgment is made to Prof. Whitaker, of the Department of Engineering Chemistry, Columbia University, for permission to reprint his excellent article on "High Explosives."

New York. February 28, 1916.

I.

INTRODUCTORY.

The writer is in no sense an alarmist. He does not believe that the cause of preparedness can be effectively served nor any permanent good achieved by a hysterical exposition of our defenseless condition, coupled with frenzied calls for immediate action. Indeed, such action, committing us by hasty and ill-advised legislation, might easily work irreparable harm.

The invasion of America, even by a nation as powerful as any of those taking part in the present conflict, is a task of such magnitude as to be undertaken only upon due deliberation and for the gravest of causes. However, the modern world moves upon trade, and in reaching out for commercial supremacy the United States may conflict with the interests of another state to such an extent as to overweigh the magnitude of the undertaking and cast the die in favor of war.

From whence our next war will come, therefore, it is not given any of us to know. In like manner none may say that we will *not* have another war. But this much seems evident, though preparedness is advisable, there is yet time for preparedness of the right sort, based upon a due appreciation of the needs before us and of the resources at hand.

It would be an insult to the intelligence of the engineers of the country to attempt to prove what is well known, that we are not sufficiently prepared for any war which might overtake us. It is therefore a waste of time to dwell upon our shortage of

equipment and ammunition or the tactical disproportion of the various arms of the service.

This discussion shall deal, therefore, with a very small part of the general subject of preparedness—the part of the engineer as an individual. It is not proposed to recommend legislation, to outline a reserve system or to insist upon military training in the schools. On the contrary, it will be assumed that Congress has done nothing, that the Army has not been increased, and that, as good engineers must often do, we shall be forced to make the most effective use of the material at hand.

Engineers, and the public in general, have become thoroughly awake on the subject of preparedness, but, contrary to the general public, the awakening of engineers means that something will be accomplished. A number of associations have passed resolutions in favor of preparedness; others, as for instance the Western Society of Engineers, have asked Federal aid in instructing their members for military duty; the great national societies have a joint committee working upon a project for a technical reserve of their members, to be called into service in time of war; and, finally, the engineers of New York City have arranged a course of instruction, consisting of seven lectures delivered by engineer officers of the Army.

All of this indicates an awakening to our national needs which is very gratifying after the public indifference which it replaces, but it must be admitted as the honest opinion of the writer that, in its present form, it is extremely improbable that all this agitation for preparedness of engineers will add a single capable soldier to our forces, or reduce in the slightest degree the confusion which would rule the country when war became imminent.

Effective preparedness lies in the *individual,* not in the association, and if each engineer sees to it that he

personally is fully prepared to take his place as an officer or non-commissioned officer of engineer troops, then may we be said to have accomplished a great step towards preparedness. The next war will be one of engineers, and upon the efficient leadership of our engineer troops will depend in large measure our ultimate success.

The work of the Engineers is divided into two great classes, that in the Zone of the Advance at the front, and that in the Zone of the Line of Communications. In the latter the works are of a more deliberate and permanent character, directly akin to civil works. Skilled civilian labor would be largely used, and civilian Engineers could be taken directly from their daily duties to supervise the construction of highways, railways, bridges, and the more deliberate defensive works for their protection. In this work the civil engineer can find a large sphere of usefulness, the duties differing little from those of his ordinary practice, except that they are directed by officers towards military ends. These men would not necessarily be commissioned, in fact, many of those best qualified would be beyond the age for commissions in the grades corresponding to the work which they would do. Let it be understood, therefore, that the writer considers such service of the highest importance, and that a Technical Reserve of members of the profession at large, immediately available for work of this character upon the outbreak of hostilities would be of great value to the country. In the discussion which follows, therefore, the former class of engineering work only will be considered, that of the Zone of the Advance, where conditions are totally different.

There is work in plenty of both kinds to be done, and one may render equally good service in either class. However, if *all* choose to work in the rear, the troops at the front will be seriously handicapped. Service along

the Line of Communications falls naturally to men of long experience and ripe judgment. That at the front requires men with physical endurance, initiative and enthusiasm, qualities ordinarily possessed in good measure by the younger generation of engineers. It is to these men, therefore, that we must look for engineer officers in our next war. The average engineer faces much preparation before he is qualified to render effective service of this character.

It has been said that the science of Engineering had its beginning when the Missing Link first used a stone to crack a cocoanut. This is probably an error in so far that the stone was used to crack, not the cocoanut, but his neighbor's skull, since it is a pretty well established fact that the first engineers were military engineers. As time went on and civilization developed, engineers were in time of peace used upon public works, and it is only in modern times that the profession of engineering has become a distinct calling. The latter is now so diversified in all its branches that one adopting engineering as a profession must be a specialist. It is beyond the capacity of any man to be qualified in all the subjects that are grouped under the term engineering.

A locating engineer could not be expected to take charge of the electrification of his own railway, and a bridge erector would hardly make a success as master mechanic of the same road; yet each is an engineer, and a railroad engineer at that. Similarly, a successful highway engineer would not be chosen to design a great bridge, nor would an irrigation engineer step into a position in charge of a shield tunneling job, and yet each of these positions calls for a civil engineer.

The military engineer makes use of *all* branches of engineering science but often in a different way and with an entirely different view point than his civilian confrère. His work is destructive as often as construc-

tive, his materials are scarce and of the crudest, and often utterly unfitted for his purpose. Plant is almost unknown, labor is plentiful but often inefficient, time is all-important and there is constant and serious interference by the enemy with each step taken. Everything must be done with a military purpose and from the view point of the military man and until the engineer acquires this point of view he cannot make a success in the field.

It must also be remembered that the military engineer is a soldier before he is an engineer. He commands troops who must be prepared to fight as infantry to protect themselves or their work. He must therefore be versed in the drill regulations and the tactical considerations governing the use of that arm of the service. He must administer the affairs of his command and look after its training, housing, transportation and sanitation. He must understand thoroughly the plain business of "soldiering" with its many details before he begins to think of using his men as engineers.

An officer in the field cannot act in a mere consulting capacity upon purely technical matters. He must be prepared to put his shoulder to the wheel and take his share of the enormous amount of routine and other necessary but uninteresting work with which the time of the military man is filled. Nor is there a place at the front for a specialist. The engineer officer must be qualified to conduct a reconnaissance, locate trenches, supervise their construction and the placing of obstacles, direct siege operations, drive a mine or sap, build roads, railroads or bridges, or use explosives, entirely upon his own responsibility.

Let us consider for a moment that a number of practical engineers have been commissioned in a volunteer reserve and that, war having been declared, one of them receives an order to this effect:

"1. Captain A. is detailed for duty and assigned to the command of Company H, Second Engineers, U. S. Volunteers, mobilized and stationed at Camp Wilson, N. J.

2. Captain A. will make immediate requisition for arms, equipment and engineer property and for transportation to Portville for embarkation with expeditionary forces."

Query: What does he requisition, of whom is it requisitioned, and how much transportation does he request to move his company at war strength and fully equipped?

Again, suppose him arrived in camp, his officers and men, volunteers like himself, just reported. The First Sergeant says, "Captain, the cooks have nothing to cook. No rations have been sent over by the commissary." The Captain hurries to his organization supply officer and complains of this manifest attempt to starve his men. He is told, "Issue call was sounded at ten A. M. and your Quartermaster Sergeant was not present. Furthermore, we have received no ration return from you nor a morning report of your strength."

Query: What is a ration return or a morning report, how do you make them out, and to whom do you send them?

And again, at the front, the brigade commander sends an urgent call to division headquarters for an engineer officer to assist in preparing a position for defense. Captain A. is favorably known to chief engineer of the division as a capable engineer and one who has studied diligently since being commissioned, so he is sent.

Knowing from his field manual that a good defensive position should afford a clear field of fire to the front, that it should provide concealment and good communications to the rear, with its flanks resting upon impassable objects, Captain A. selects a position forward of

the crest of a slope, lays out complete trenches with overhead cover, sods them over, places entanglements at the foot of the slope, and carries the line from the river bluff on the left to contact with the lines of another brigade on the right. The attack is then awaited in confidence.

But when the men have dug themselves in, a swell in the ground completely blocks off from view the foot of the slope and considerable space in front and rear, and the entanglements, so plainly visible to Captain A. on his horse, are in the middle of a dead zone, to which the enemy advance by rushes, line after line, and destroy the entanglements at their leisure. Spurred on by their officers the men leave their elaborate trenches, advance to where the enemy is visible and open fire from a prone position, only to be driven back by shrapnel from the enemy's artillery, firing over the heads of his own troops. They are followed up the hill by masses of the enemy's infantry, who rush the trench before it can be reoccupied, drive the defenders back in headlong flight, turn the flanks of the adjacent brigade, and the day is lost.

These few instances are not exaggerations. Those who served in the Spanish War can multiply occurrences of the first two kinds and many an officer of more experience than Captain A. has been guilty of the same neglect, of locating trenches without placing his eye at the level of the men who will occupy them.

In recent articles of the technical press it has been urged that practical engineers, contractors' men, construction foremen, etc., were as well or better qualified to perform certain classes of work than regular engineer troops and could be used for this work without further training. This is admitted, but can they outside their special lines perform *all* the duties that fall to the engineers, including *fighting*, as well as troops possessing a more general training? These men have

made the United States famous wherever engineering work is done and their knowledge and experience will be a tower of strength to the army. But consider how much more effective they would be if each were trained as a soldier as well as an engineer; if he possessed a familiarity with the different technical duties of the military engineer *in addition* to his own specialized knowledge.

Let us imagine that all members of the engineering profession who are of military age and physically fit have studied and attended instruction camps, lectures, etc., until they are really fitted to command engineer troops. Does this knowledge on their part tend to lessen the confusion and complications incident to their recruiting, mobilization, mustering into service, commissioning and assignment, taking command and welding their organizations into efficient units? Yet this must be done before they can become efficient officers. If they simply enlist and serve in the ranks their training and talents are in a measure lost by not being fully developed, and we still have the work of bringing them into the service.

It must be admitted that a mere expression of willingness to serve is not sufficient unless backed by *individual* service and preparation along the lines of military as well as engineering efficiency.

Congress is contemplating measures of preparedness. There are many who await the result before deciding what they, individually, will do. Opinions differ, and the legislative battle will be a long one. Any measures adopted will take months to carry out, and results are at any rate uncertain. In the meantime we have the National Guard, which is a *going concern*, and which is working to the same end. That the National Guard has its faults is admitted, but so has the Army; that those of the National Guard are the more serious cannot be denied, but it must be conceded that the re-

sult in each case is *due to conscientious effort,* and is probably the best that can be done under the circumstances. However, the faults of the National Guard are due not so much to inside as to outside causes, not the least of which is the attitude of the general public towards the Guard. We cannot have full companies if public sentiment does not favor enlistment, we cannot have full attendance at maneuver and instruction camps if employers will not let their men off, and we cannot have efficient organizations if the men who can make them so refuse to enlist.

But in spite of all its faults the National Guard can be made a powerful factor in our defence. These men *are* organized, they *are* under arms, they are equipped *exactly* like the Army, and receive instruction of the *same* character out of the *same* text-books. The Guard today, faulty as it is, still forms the most practicable. and in fact the *only practicable method* we have of promptly reinforcing the Regular Army in time of war.

So therefore if the engineer intends to join the Continental Army or an Officers' Reserve he may, instead of marking time until all the legislation and plans are perfected, improve his time by qualifying for the position which he may desire to hold. The proposed law authorizing these forces contemplates drawing largely upon the National Guard for officers, and one can certainly lose nothing by advance preparation.

II.

HOW TO OBTAIN A MILITARY TRAINING.

Considerable space has been devoted to showing that the civilian engineer who wishes to become a potential military engineer must first obtain a military training. It is therefore essential that there should be outlined some practical manner in which this training may be obtained.

There are a number of methods which have been suggested, each of which has its advocates, and each of which has its good and bad points. Those which have been recently urged are: the Army, college training, home study, instruction camps, and the National Guard.

The Army. Compulsory training in the Army is objectionable to the people because of its cost, because many men would be withdrawn yearly from productive pursuits, and because of the fear of all that suggests a military form of government. Universal service may be the eventual solution of the problem of preparedness, but it must come gradually, and probably by way of compulsory *militia* training. The American people are not yet ready for it. Even if such legislation could be secured, it would be a long time before we could reap its first benefits. It does not, therefore, lie within the scope of this discussion, which aims simply to point out the manner of utilizing most effectively the facilities we now have.

For the engineer to drop his business interests and serve in the Army as now constituted, in order to obtain the military training necessary to qualify himself for a volunteer commission is not advisable. The soldier who does his full duty, and learns thoroughly all

the details pertaining to his position, does not qualify himself to become an officer. Even those men who graduate from the ranks into a commission must pursue a course of study entirely outside their ordinary duties as soldiers. An engineer who enlists in the Army, therefore, expecting after a term of service to enter an officers' reserve, will find himself confronted by examination questions upon matters of which he heard nothing as a soldier, no matter how conscientiously he applied himself.

The duties of a soldier are one thing, those of an officer are another, and the difference is great. They do not merge, and proficiency in the lower grade is no guarantee of qualification for the higher.

College Training affords a splendid opportunity if properly conducted. Nearly all the large engineering schools offer facilities for military training, and in the Land Grant Colleges, i. e., those which received grants of public lands for the maintenance of their Agricultural Schools, military training is compulsory. Most schools of this character, where the students drill a certain number of periods each week, and the work is supervised by an officer of the army detailed for that purpose, are rated as Class "B" by the War Department. The students are under no military control outside the drill hour, and the instruction is about on a par with the infantry drill of the better National Guard organizations.

From six years military experience in a typical university of this character, and from considerable information gained by conversations with students of similar institutions the writer can advisedly say that he does not believe that the instruction, as now carried out, offers the proper training to qualify young men for field service as officers of engineers.

The drill comprises infantry tactics and close order formations. There is very little rifle practice, and no

real instruction in the principles of musketry. In winter, when the weather prevents outdoor drill, there is indoor instruction, mostly in the Infantry Drill Regulations. A few advanced students may receive lessons in Minor Tactics and the Art of War, but these are limited to the cadet officers, who have elected to serve for a longer period than the university regulations require. The percentage of the total force which receives other than elementary infantry instruction is therefore very small. Finally, field service is entirely lacking in every case of which the writer has received information.

There are a number of military institutions in the United States which are rated as Class "A" by the War Department, and in which the military instruction is of the highest order, ranking second only to the Military Academy itself. However, these schools are mostly in the preparatory class, and are famous principally on account of their military character. None of them is numbered among our leading technical institutions. Even at West Point the engineering instruction is very limited in its scope, and officers graduating into the Engineers must take a post-graduate course in engineering at the Engineer School of Washington Barracks, D. C.

It seems evident, therefore, that if our engineers are to receive an adequate military education along with their engineering course, the scheme of military instruction must be considerably modified, probably along the following lines:

1. Its scope must be extended, and military instruction required throughout the undergraduate course. As much attention should be paid to work in the class-room as to that on the drill ground, and a regular curriculum should be followed, embracing supply, organization, administration, minor tactics,

field service regulations, field engineering, *and military history.*

2. Less time must be allowed for infantry drill, and the portion which is so occupied must be devoted partly to extended order drills, not on the level campus, but on terrain approximating field conditions.

3. The drills, outside of infantry tactics, should include military topography and sketching, in which the engineer is usually wofully deficient, rifle practice, and the underlying principles of *rifle instruction.*

4. Finally, the student should be required to attend one of the college men's instruction camps held by the War Department. Students from the technical schools could be accommodated in engineer camps, directed by engineer officers of the Army and assisted by engineer troops, similar to the instruction camps of the militia engineers. Such field service would be productive of a much higher efficiency than local encampments, managed entirely by the university authorities.

A man completing such a course should be fully qualified to lead engineer troops in the field, but the mere fact of his having taken the instruction is not conclusive evidence of his qualification. Many men walk through a technical course, receiving a diploma at the end, without being in the least qualified to practice engineering. It is right and proper, therefore, that the War Department should require a qualifying test before admitting a graduate under the system to an officers' reserve.

Nor does the responsibility of the War Department cease here. All this training is in a fair way to be lost to the country if the proper office does not keep in touch with the graduate, send him orders and literature pertaining to his branch of the service, and encourage him to attend further instruction camps or to join the National Guard and pass his training on to others. Above all, there should be required of him, not only his

changes of address, but a periodical report, upon a printed form, which will insure complete information at all times as to his health, whereabouts and any other data which would affect his availability for prompt service. In turn, the reservist must be notified of the *cadre,* or skeleton organization to which he is assigned, and the locality where he is to report upon notification.

Furthermore, in order to prevent deterioration, and to insure his keeping up with military progress and developments, he should be required to report at certain intervals to be examined for a higher grade. Upon failure to pass this examination, his connection with the reserve should cease. Judging from the busy life of the average engineer several years out of college, how many would remain on the reserve list under these conditions until they reached, say, the grade of captain? And yet these conditions, severe as they seem, are absolutely essential if we desire an officers' reserve, which shall be capable of rendering *prompt and effective* service when called upon.

This, in the opinion of the writer, is the fatal defect in the system of college training. It is a simple manner to train these men. There is a precedent for each step outlined, and it can all be accomplished without further legislation. The Government requires military training in return for Federal aid to the agricultural schools, then let it specify the character of this training. The War Department has established college men's camps of instruction, then let them arrange to accommodate the technical men in an engineering camp. The Division of Militia Affairs of the General Staff, under the provisions of Sec. 23 of an Act of Congress of January 21, 1903, has examined applicants for volunteer commissions and placed those who passed upon a reserve list, *then let it keep in touch with these men.*

Unless this matter is thoroughly carried out, the

whole system fails. We train the men, lose track of them, and never know who or how many can be counted upon in an emergency. Furthermore, a scheme of skeleton units is a prime requisite, if we would avoid the confusion of organization after the beginning of hostilities.

Yet, with all this accomplished, the training, the close contact, and the organization, ready for immediate response to a mobilization order, the whole structure still rests upon the self-discipline and sense of responsibility of the individual engineer, who, busy with making a living and a career for himself, must study privately, keep up with military progress, for the military art makes long strides even in times of peace, and prepare for promotion examinations, merely upon the chance that, sometime, his services may be required.

Moreover, while an improved system of college training may be of great benefit in preparing future generations of engineers for volunteer commissions, it is not available for those who have already completed their college courses and are now engaged in active practice. Many of these are anxious to serve and, properly trained, could render very effective service.

Home Study, amplified by lectures, is the favorite plan of many engineers in this country. The causes of this preference are easily seen:

1. There is no compulsion to take instruction except as desired and as perfectly convenient to the individual.

2. There is no supervision over his work and no test to pass, so he is not bothered with monotonous details, and can study only what interests him.

3. There are no responsibilities, no formations to attend, no duties to perform, and no restraint upon his liberty.

These very reasons are sufficient to condemn the

method so far as any practical benefit is concerned. A man will study only when it pleases him to do so and then only that which interests him, and even a course of reading would find few to follow it conscientiously to the end. There are, furthermore, many things connected with military service that cannot be learned by study alone, as will be seen later.

And how are such men to be made available for service? They apply for commissions upon the outbreak of hostilities, and find that they have no standing with the War Department. They cannot submit a record of any connection with a reputable military organization, nor even a certificate from an examining board. To examine and classify them at this late hour would be impracticable, and the War Department would hesitate long before commissioning a man with absolutely no military experience. The probable reply to such application would be, "Gentlemen, we have a place for you—in the ranks."

Training Camps are a development of the college men's camps which originated in 1913. The few that have been held so far have been eminently successful in imparting to a number of men the rudiments of field training by means of an intensive method, and have aroused great enthusiasm among those attending.

In these camps the men are by degrees accustomed to the long marches and the full pack. The time at their disposal, usually thirty days, easily permits of this, and the results are quite different from those obtained by the average militia organizations on maneuvers of perhaps a week's duration, where the rule is a full pack and usually a march of fair length from the very beginning.

The most famous camp, that of the "First Training Regiment," at Plattsburg, N. Y., attracted a large number of men prominent in various walks of life, and the course of training was carefully laid out to illus-

trate the problems which will confront troops in the field. The success of the camp was largely due to the type of men attending and the intelligence displayed in grasping the principles involved as well as to the tact and hard work of the officer instructors.

After the day's drill it was customary to hold lectures upon military subjects, mostly explanatory of the drills and maneuvers executed during the day.

The attitude of the daily press was probably the one objectionable feature of the encampment. The camp was hailed as the last word in military education, grinding out fully trained officers in thirty days' intensive instruction. That this attitude was not shared by the men themselves nor contemplated by the army officers who were their instructors is easily seen from their writings and public utterances. The above mentioned press items, however, might be productive of much misunderstanding on the part of prospective participants.

It is conceded that a man of natural ability, accustomed to handling men, might learn enough of field conditions at such a camp to carry him successfully through a campaign as a company officer of volunteers. But unless he has had previous military training, it is certain that he must take the field lacking in *some* of the knowledge that an officer should have, and if the exigencies of the campaign do not call for exercise of this knowledge at some critical moment, he is fortunate. For a man who has undergone military training in college, and has had experience as a cadet officer, the training camp would furnish the necessary field service to complete his military education and fit him for a volunteer commission.

That field service alone, however, of limited duration and unsupported by previous training, can fully prepare a man to lead troops in modern warfare, is a pro-

position not to be seriously considered. The following quotations may throw some light upon the subject.

The first is from a circular issued by those in charge of the training camps for the summer of 1916, and shows their view-point as to the scope of the instruction given:

*"The aim is to give men of average physique four or five weeks *a year* of intensive military instruction under officers of the Regular Army, so that at the end of that time men of no previous military experience will, at least, have learned the *rudiments* of military organization and discipline and use of the military rifle, and become *somewhat* familiar with the equipment, feeding and sanitary care of an army in the field, and the handling and control of men in maneuvers."

The second is from an anonymous article reviewed in the *International Military Digest* for February, 1916, and presents the views of a member of the *First Training Regiment* at Plattsburg.

"Note. This is written from the standpoint of a 'rear-rank private' at the recent camp of instruction at Plattsburg, N. Y.

'Our first reflections concerned organization. Here we were, thirteen hundred eager, unskilled men from civil life, parodying what happens when our country goes to war. A miracle of transformation was wrought upon us. In two days we had ceased to be a mob. In a week we had got by the first appalling fatigue. In a fortnight we had developed out of nothing our own noncommissioned officers. Three weeks had made an effective if ragged regiment of us.

" 'It needed little reflection to see that the health, order, and spirit of Plattsburg could never be improvised. These depend upon long founded experience and intelligence. I imagined what would befall us if all the cooks, doctors, officers, and regular

*Italics are the author's.

privates were suddenly withdrawn and the 'Business Men's Regiment' left to its own devices. Even in time of peace the result would be calamitous.

" 'A more ominous reflection came on the first day of combat tactics in open order. Suppose this were not the end of the drill, after two weeks of amateur soldiering, but the beginning of a battle, after two weeks of real war. Who would teach us to shoot twice a minute and to roll over in changing position when to rise were death? Not our present captain and lieutenant, not our smiling and steely-eyed regular sergeant, but just willing duffers like ourselves, fighting by day and learning how to fight out of 'Infantry Drill Regulations' at night. As things go in modern war, should the regular army have to face a powerful foe, there would in a month be no regular army. The funded military intelligence of the nation would be shot to pieces in just about four weeks. The men who could make soldiers out of the million men, who we are assured would spring to arms, would be themselves in soldiers' graves or lying unburied.

" 'To imagine ourselves in any sense protected because the American is a natural fighting man is the last folly.

" 'After a month we could march, camp, shoot, take care of ourselves, maneuver a few hours a day. I think that perhaps a quarter of us had hardened enough to do much more than required of the regiment, but most of us were still far from fit it to stand the physical strain of actual warfare. Here is a whole side of preparation for war about which there is the wildest misconception. People cannot realize that a stalwart untrained citizen is no more physically fit to fight than a sturdy untrained freshman is fit to step into a football match.' "

That field training alone is not the best system of developing officers is recognized by the War Depart-

ment in the course of instruction followed at West Point. Instead of living in camp for a year, undergoing intensive training, and then receiving their commissions in the Army, the cadets are given a thorough theoretical course along with their practical work.

The soldier's instruction comprises rifle shooting, physical drill, marching, camping, sanitation, care of self and equipment, drills in the tactical duties of his branch of the service, *and discipline.* There is nothing in this list that cannot be much better taught in the field than in barracks, and field training is therefore ideal for the enlisted man, but an officer must know more.

The prospective officer studies the Art of War, so that, instead of blindly leading his troops as he is told, he has some intelligent idea of the purpose of it all. He studies Military History, for there is no better preparation for conducting campaigns than by the study of past operations. Napoleon was a great believer in the efficacy of study as preliminary to leadership, and is on record as having shown marked preference for a man known to be a deep student of military science over one of much experience but little military education.

The student officer must also learn the theory of his practical work. A soldier may know the mechanical processes of making a road sketch, but the officer must know the principles of surveying involved, in order to become an *instructor;* the soldier may be able to construct a satisfactory firing trench, but *some officer* must decide where that trench is to be located, and the type to be constructed, in order to best attain the desired result; a sergeant may erect a spar bridge, using timber of the correct size to carry the load safely, but is was an officer who *first computed* the sizes of timber necessary for the various spans, and put them in the

Field Manual where they became accessible to the sergeant.

In short, the officer must acquire a considerable theoretical training and, while his education is not complete without field service, neither is the latter sufficient in itself. It is told of von Moltke that he valued exceedingly an old black-board in his quarters. Upon this board he worked out problems in tactics, strategy and map maneuvers; laying out hypothetical situations, considering the conditions and location of his own forces, similar data regarding the enemy, preparing a plan of action, and writing out the necessary orders to his subordinates to carry out the plan adopted. To this training he largely attributed the great success of his campaigns in the Franco-Prussian War.

Finally, the whole question of volunteer officers reduces itself to one of expediency. If a sufficient number of fully trained officers are not available, then we must make use of the best material we have, and in such a case many graduates of the training camps would undoubtedly receive commissions. While not possessing all the qualifications that could be desired, these men would be vastly preferable to the political appointees who officered many of the volunteers in the Spanish War.

To the prospective training camp recruit, therefore, the following advice may well be given.

1. If you have an opportunity of attending this camp, do so, and go again each summer if the camps are held, for there is something you can learn at each tour of duty.

2. Do not imagine that your service *entitles* you to a commission, but work as if it were certain that you *would* command troops in our next war, and make it a point to learn *all* that you can regarding an officer's job.

3. Supplement your field training by home study.
4. If you can possibly do so, follow up your training by joining some National Guard organization.

It has been urged that National Guard officers, as a class, regard the system of Training Camps as a sort of unfair competition to their efforts at building up their own organizations, by offering more attractive service and precedence in the matter of volunteer rank, without the disadvantages and inconveniences of service in the National Guard. The following letter from the Commanding Officer, National Guard New York, to the Officer in Charge of the Military Training Camps, published in the descriptive circular of these camps, is self-explanatory:

"HEADQUARTERS N. G. N. Y.

New York, January 17, 1916.

"The question is sometimes asked whether there is any conflict of interest or of effort between the organizations of the National Guard and the training camps for college and business men. This question may not only be answered emphatically in the negative, but may be affirmatively stated with equal emphasis that the training regiments have been of benefit to the National Guard, of this State at least. A very considerable number of men of the Plattsburg training regiment have joined organizations of the New York Division, some as commissioned officers and some as enlisted men.

"Wholly aside from the foregoing there is another aspect of the training camps which should not be lost sight of. There are in some localities men who desire military training, but who are so circumstanced that they cannot make available for the purpose the amount of time demanded by service in the National Guard. Some of the men in this class find it possible to devote thirty days for training during the summer

months. The training camps furnish the needed opportunity for men in this class. These camps are therefore performing a service to the nation in respect to such men, which it is not possible for the National Guard to perform.

"I have no hesitation in urging upon officers of the National Guard throughout the State their fullest cooperation in support of the excellent movement represented by the training camps. In New York State facilities have been provided in some of the armories for detachments of men of the training camps who desire to continue the work begun at Plattsburg.

(Signed) JOHN F. O'RYAN,
Major General, N. G. N. Y."

At the beginning of this chapter there were listed five ways in which a military training might be obtained, four of which have been discussed. That remaining, the National Guard, will be treated of in the following chapter.

III.

THE NATIONAL GUARD.

The land forces of the United States as at present constituted (February, 1916) consist of:

1. The Regular Army.
2. The Organized Militia (National Guard).
3. The Volunteers.

History. The militia comprises all able-bodied male citizens between the ages of 18 and 45, and under the Constitution Congress has the authority to call forth the militia for the purpose of executing the laws, suppressing insurrection and repelling invasion, also to provide for organizing, arming and disciplining the militia and for governing such part of them as may be employed in the service of the United States, reserving to the states the appointment of officers and the authority of training the militia according to the discipline prescribed by Congress.

It was originally required that the militia be mustered once a year, after which there would be a drill by some former officer of the Army or by some officer elected or appointed from among the militiamen. The evolutions executed on these "Training Days" were fearful and wonderful to behold, and yet these were the only forces that stood between the United States and absolute annihilation, there being practically no Regular Army at this time.

The action of the militia has been most disgraceful in every war in which they have been engaged. All during the Revolution they were sent to the army in large numbers by the various states, and promptly de-

serted when harvest time came or when they tired of the service. In the War of 1812 a force of 2,500, largely militia, abandoned the National Capital to a force of 1500 British, after a loss of 8 killed and 11 wounded! Short term volunteers have invariably insisted upon leaving for home immediately upon the expiration of their term of service, regardless of the military necessities of the moment. The cause of these defections is apparent—lack of training, and it is due to these very glaring faults of the system as it then existed that the militia worked out its own remedy.

There were in those days men who had military foresight, just as there are at present, and these men, many of whom had served in the Colonial or Indian Wars, began, as a protest against the burlesque drills of the annual "Training Days," the drilling of independent companies and troops of men from their own neighborhoods. These organizations, which had no connection with the War Department, were maintained at their own expense, and were soon able to completely outshine the militia in their annual drills. Some of the smaller units were eventually combined into battalions and regiments, uniforms were adopted, and the *National Guard,* as they called themselves, became the beginning of a disciplined force.

The War Department, recognizing the increased efficiency of these troops over the raw militia, eventually admitted them into the scheme of the nation's land defenses, though at first with little supervision and practically no support. The states, also, encouraged the movement as tending toward a better training of their militia, and early acquired supervision over the National Guard. There was no authority for Federal control except as a portion of the militia, so the term *Organized Militia* was applied to those forces which were organized and under arms, to distinguished them from the great mass of the *Unorganized Militia.*

Even then, however, the National Guard was not highly etsteemed as a national force. Its functions were largely social; and its tours of field service were characterized by much pomp and display. Effective use of the rifle in executing the Manual of Arms took precedence over its use as a fire-arm, and the drill was largely confined to close-order infantry formations. In the scheme of defense it was contemplated to call out the Organized Militia only *after* the Volunteers had been recruited and mustered into service. In fact, it was looked upon as a home guard, not intended for active service.

The Spanish-American War gave the National Guard its real awakening. Many organizations which desired to volunteer bodily found that they could not be mustered intact into the service of the United States, but must volunteer individually. There was no machinery for taking over the various regiments and companies as organizations, so that practically the same confusion resulted as in the enlistment of volunteers, each man being required to enlist individually. In the field it was found that armory drills had not fitted the men for the hardships of tropical campaigns, nor to combat successfully the camp diseases which attacked the mobilized troops.

The National Guard of To-day. With the end of the war and the reorganization of the Army, came a call for increased efficiency in the National Guard. By means of the so-called Dick bill (1903), the Organized Militia became a portion of the first line of defense, to serve with the Regular Army and to be called out in advance of the Volunteers. Advancement has since been rapid. All organizations are now inspected regularly and judged by their field efficiency alone. Joint maneuvers with regular troops have similated war conditions. Officers of the militia have been admitted to the Service Schools of the Army, and have later ren-

dered valuable service as instructors in their own commands. Army Officers of the various arms of the service have been appointed Inspector-Instructors to corresponding troops of the militia, resulting in great profit to the latter and in greatly increased fellow feeling and understanding between the two services.

The Organized Militia of to-day is a far cry from the "Hay-foot, Straw-foot," drills of the early 19th century.

Defects of the National Guard. But much as the National Guard has advanced, there are yet great strides to be made before it can justify itself as a first-line defensive force. There are excellent organizations in the Guard, and there is much individual excellence, but as a whole it leaves much to be desired.

Inefficiency, as applied to an organization, must be considered as a relative term. National Guard troops are not as efficient as those of the Army; various organizations of the former are less efficient than others; while any one of these units is vastly more efficient than the militia of Colonial times. To dub a regiment or company "inefficient," therefore, does not necessarily mean that it is utterly worthless, and incapable of improvement.

In any war that we might have, with even a small state, the Army and Organized Militia combined would be insufficient, and we should have to call out numbers of volunteers from the Unorganized Militia. These men, if rushed to the front without adequate preparation, would be about on a par with the militia of Washington's time, with this exception: *Washington's militia knew how to shoot and to live out of doors.*

The first serious defect in the militia therefore, lies in its size. The training, however thorough, cannot suffice if we must in the end depend upon troops who have had *no training.* The theory of militia service is excellent. The men are not taken away from productive

pursuits for two years at a time, as in case of compulsory service in the army, and the expense is much lighter than where the Government must pay for the full time of a man, in addition to housing, clothing and subsisting him. A much larger force can be maintained, therefore, than would be possible in a standing army. At the same time, the Government must expect to receive less in the way of efficiency than from troops who devote their whole time to military matters. If the Federal Government is willing to stand the increased cost, the Organized Militia can be expanded to the size necessary to properly reinforce the Army. It has been estimated by the General Staff that ten militiamen can be maintained at the same cost as one soldier, so that an increase in the militia of 500,000 men would cost no more than 50,000 additional soldiers. Half a million *partially trained* soldiers would probably be more effective at the outset of war than a *highly efficient* force of 50,000 regulars, who would be cut to pieces in the first battle.

It is not believed that the recruiting of such a force will present insuperable difficulties. The National Guard is now looked upon as an aggregation of military enthusiasts, who join simply to gratify their love of playing soldier. The distrust of the War Department is reflected in the general public, and the busy citizen regards the service as a form of recreation, which *may* become exceedingly annoying by making inconvenient demands upon his time. If it were realized by the average man that his work in the militia *would not be wasted,* but would count towards national defense, and that the War Department depended upon the National Guard and considered it an integral part of the land forces of the United States, then many of the objections to membership would be removed. This establishment of the true status of the National Guard, and giving it a serious and well understood role, would,

in the opinion of the writer, do more towards filling its ranks than the expedients of Federalization and regular pay for its members.

The basic principle of the National Guard is *voluntary service,* and this the average citizen is willing to give, even at considerable inconvenience and expense to himself, if he knows that he will be taken seriously and his work appreciated.

That Federalization and Government pay will accomplish much cannot be denied. Uniformity of control will be assured by the former, and the War Department will be removed from the position of supporting and instructing a force upon whose service they cannot absolutely depend in time of war. The matter of Federal pay is questionable. It will undoubtedly lead to a closer accounting for property, and will compel better attendance. It will also enable the War Department to demand more in the way of qualifications for warrants and commissions, and in the amount of duty required. Most officers of the writer's acquaintance do not favor pay for themselves, fearing that the additional duties required to earn it would make prohibitive demands upon their time. Nearly all favor pay for the enlisted man, as reimbursing him in a measure for the cost of his service, company dues, car-fare, repairs to his uniforms, etc, and as a means of enforcing a stricter responsibility for the property which is issued to him. The main objection is the same as for the officers, that the pay will bring such disadvantages in the way of increased duty as to defeat its own purpose and discourage enlistment.

The Organized Militia is the only force we have which even approximates the Regular Army as to organization, equipment and training. It originated entirely as a volunteer force, without the support or even the official recognition of the War Department. It forced this recognition by marked superiority over the

old system. It has tried hard to free itself from the out of date legislation which hinders its development in order to justify its claim to consideration as a defensive force. Above all, there is not now a single officer or man in the service but who has enlisted with the idea of some day fighting for his country. *In spirit* the Guard is a national force. To secure to the nation the results already accomplished and to give an incentive to still further efforts, there should be no hesitation in making it one *in fact*.

But even if no change be made, if the militia be forced to stumble along as heretofore, without the slightest idea of their status in war, and no officer sure of his commission after muster into the Federal service, there is still much that can be done in the way of effective preparedness. Though organizations as a whole may not be acceptable to the War Department, owing to the legal difficulties of their transfer from state to Federal control, yet in a serious war every man with military training will be welcome *as an individual*. It may indeed happen that, through the great expansion of our forces, he would hold much higher rank than his experience justified, simply because of the great number of vacancies and the scarcity of qualified men to fill them.

The War Department does distrust the National Guard as a force upon which much reliance could be placed in time of war, and perhaps with good reason. The governor of any state, not in sympathy with the policies of the party in power at Washington, may carry his antipathy to the extent of desiring to embarrass the Administration even at a serious cost to the nation. It is within his power to disband entirely the Organized Militia of his own state in the face of impending war. Furthermore, if accepted bodily into the Federal service, the militia would be commanded by a number of general officers, of whom practically

every state has a few, many of whom are political appointees purely, have no preliminary training in the ranks, and are absolutely unfit for the commands to which their rank would entitle them.

This is probably the most serious obstacle in the way of an organized militia ready to take the field intact. It can possibly be remedied by Federalization, in which case the higher officers would be detailed from the Army or appointed upon qualifications specified by the War Department.

It will thus be seen that the main objections to the National Guard deal only with its system of control, and not with its personnel and training. In fact, the training, as far as it goes, is identical with that given the Army. It is prescribed by the War Department, carried out under the supervision of Army officers, and followed conscientiously during the time available. There need be no fear, therefore, that one will receive incorrect or out of date instruction in the National Guard.

Engineers of the National Guard. To one seeking a military training, particularly to the technical man who desires to qualify for an engineer commission in the volunteers, there can be no better course than enlistment in the engineer corps of the militia. These organizations are few in the country, comprising only about 20 companies, 12 of which are organized into 3 battalions. The War Department is very anxious, however, to establish more engineers in the militia, and will gladly render assistance to any body of engineers desiring to form a company. Full information as to the proper proceedure may be obtained from the DIVISION OF MILITIA AFFAIRS, GENERAL STAFF, U. S. ARMY, WASHINGTON, and the ADJUTANT-GENERAL of the state concerned.

In the New York National Guard there are eight companies, organized as one Pioneer Battalion and one

Ponton Battalion. Their housing and equipment are exceptionally complete and up to date. And yet, in New York City, where more engineers are gathered than in any city in the United States, the rolls of these battalions have in the past included painfully few technical men. Even now, with engineers fully awake as to the necessity of preparedness, there is a marked reluctance to enlist. Some fear that their work will be wasted, others that it will interfere with business, but the main reason is a lack of information among engineers as to the true meaning of service in the Engineer Corps. The issue is obscured, moreover, by the numerous substitutes which are offered for National Guard service.

It must be realized that if any effective preparedness is to be accomplished by the engineering profession, it must be based upon *individual effort*. If *each* engineer is prepared to perform his work in war, then *all* are prepared. The question of what is to be done does not depend upon Congress, the President, or the War Department. It rests with each engineer to decide *for himself*, whether *he* shall take effective steps to prepare, leaving the question of his neighbor's preparedness for the neighbor himself to decide, or whether he will let the other man prepare while he holds back.

There is no royal road to military knowledge. It must be obtained through some military organization. Every cadet that enters West Point must serve as a private in the cadet battalion, and undergo the same discipline as a soldier in the army. Engineers have had their schooling, and are now engaged in business and professional work and the only practical course open to one such who seeks military training is enlistment in the engineers of the National Guard. For the sake of its very existence, the Guard cannot presume to interfere with the business or means of livelihood of its members; honest effort to learn will receive every en-

couragement and assistance from those in authority; and all work done will count towards a useful end.

As in the Army, a private learning thoroughly his own duties does not qualify himself for a commission, but there is this difference: a private of militia spends perhaps two hours a week learning to be a good private, but he has all the remaining time he can spare to devote to higher study, and no matter how much additional instruction he desires, he will always find some one willing to give the time necessary to impart it.

It is not the policy of the National Guard to belittle the work done by the Boy Scout movement, the college training, citizens' rifles clubs or the summer training camps. The Boy Scout movement accomplishes a great good in teaching boys elementary woodcraft and that respect for authority which is so often lacking in the younger generation. College training, if properly conducted, can do much in the way of developing soldierly qualities during the character-forming period of a young man's career. Citizens' rifle clubs not only foster a noble sport, but tend to develop a most essential part of military training. Summer camps, as before stated, can reach men for whom other military training is impracticable, and also contribute towards the awakening of many to a sense of the duty they owe their country. Rather are these movements regarded as supplementing, or leading up to, the work done by the National Guard, than as substitutes for it.

Let it be well understood that any man who may possess the smallest part of a military training will reduce by that much the preliminary drill which will be necessary to make an efficient soldier of him when war is declared, and any system which imparts this training is rendering a useful service. But there will be great need for men with *more* than a partial training, and the *greatest* service is therefore rendered by the system which imparts the *most complete* training.

IV.

MILITARY ORGANIZATION.

Military organization is of necessity the most centralized and complete system known. There is an unbroken chain of responsibility reaching from the commander-in-chief down to the rawest recruit. At the same time there is a continuous line of succession extending through all the grades and ranks, so that, however heavy the casualities, there is always one leader, and only one, to whom the army may look for orders.

In order to secure concerted action and immediate response to the will of the commander, soldiers, both officers and men, voluntarily subject themselves to *discipline,* which Col. Wagner, in his "Art of War," defines as follows:

"Discipline is that quality possessed by efficient soldiers, which enables each to appreciate and accept without question the powers and limitations of his own rank, which inspires each with confidence in the military steadfastness of his comrades, and renders obedience to lawful orders a second nature."

ARMY ORGANIZATION.

The Army is made up of two main divisions: the *Line* and the *Staff*. The latter is charged with most of the administrative work, the former with the actual fighting.

The Staff. The various Staff Departments are:

The *General Staff,* which prepares all plans for defense and mobilization, investigates all questions affecting the efficiency of the Army, and acts in an advisory capacity to the Secretary of War.

The *Adjutant General's Department,* which handles all orders, correspondence and records of the Army.

The *Inspector General's Department,* which inspects and reports upon all matters affecting the efficiency of the Army, the condition of property and supplies, and the expenditure of public funds.

The *Judge Advocate General's Department,* which is the legal bureau of the Army, and has charge of all records of general court martials, courts of inquiry, and military commissions.

The *Quartermaster Corps,* comprising the former *Quartermaster, Subsistence* (Commissary) and *Pay Departments.* This corps is charged with the transportation, clothing, housing, subsistence, supply and pay of the Army, and with all duties pertaining to military operations which are not specifically assigned to some other department.

The *Medical Department,* which supervises the sanitary condition of the Army, physical examinations, care of sick and wounded, and the management of military hospitals.

The *Ordnance Department,* which supplies arms, equipment and ammunition to the Army. This department designs and manufactures fighting material of all kinds, field equipment, horse equipment, etc., and maintains the arsenals where this material is made, repaired and stored.

The *Signal Corps,* which constructs, repairs and operates all military telegraph and telephone lines and cables, balloon trains, aeroplanes, etc.

The *Corps of Engineers,* which surveys and maps the terrain, plans fortifications and field works, and lays out lines of communication. Engineer officers of the Staff should be distinguished from those serving with troops, who are a part of the Line.

Staff officers hold military rank as do those of the Line, but do not exercise command unless placed upon duty under orders directing them to do so.

The Line. The Line comprises the fighting troops,

the *Infantry,* or foot soldiers; the *Cavalry,* or horse soldiers; the *Field Artillery,* which accompanies the Army in the field, the *Coast Artillery,* which operates the coast defenses, and the *Engineers,* who perform the duties outlined in Chapter VI.

The Line is composed of Officers, who exercise command by virtue of *commissions* issued by the President, (or, in the National Guard, by the Governor) and the *enlisted men.* The latter include *privates,* and *Non-Commissioned Officers* (Sergeants and Corporals), who exercise limited authority by virtue of *warrants* issued by their Commanding Officers.

The *Non-Commissioned Staff* of a Post, Regiment or Battalion consists of the *Sergeant-Major* and the *Quartermaster Sergeant.* The Sergeant-Major's duties correspond to those of a *first sergeant.*

TACTICAL ORGANIZATION.

A *squad* comprises seven privates and a *corporal.*

Three or four squads form a *platoon,* commanded by a *sergeant* or a *lieutenant.*

Four platoons form the *company,* which is commanded by a *captain* and is the smallest administrative unit of the army.

Four companies form a *battalion,* which is commanded by a *major,* and is the smallest unit which will operate independently in the field. The staff of the major comprises an *adjutant* and a *supply officer* (quartermaster).

Three battalions form a *regiment,* commanded by a *colonel.* A *lieutenant-colonel* may command any fraction of a regiment greater than a battalion. Regiments of engineers are not now authorized in our service. The staff of a colonel consists of an adjutant and a quartermaster.

Three regiments form a *brigade,* commanded by a *brigadier-general.*

An *infantry division,* commanded by a *major-general,* is a complete army in itself, and comprises three brigades (nine regiments) of infantry, one regiment of cavalry, one brigade (two regiments), of field artillery, one field battalion of signal troops (one wire company and one radio company), one pioneer battalion of engineers, sanitary troops, and wagon trains. The strength of an infantry division as now constituted (Feb., 1916,) is 22,665 officers and men, 7,447 animals, 48 guns, 853 wagons, and 40 machine guns, and it occupies 15.4 miles of road on the march. The trains comprise *field trains,* carrying camp baggage and rations, a *supply train,* an *ammunition train,* a *sanitary train* (*ambulances, etc.*), and an *engineer train,* of reserve intrenching tools for the infantry.

The Engineer Train is composed of nine wagons, one for each regiment of Infantry in the Division. Each wagon contains the following equipment:

Items.	Number.	Weight, Pounds.
Axes	26	130
Crowbars	7	84
Nails, pounds	—	95
Pick Mattocks	149	671
Sand Bags	450	256
Saws, hand	13	21
Saws, two-man	13	52
Shovels	298	1,200
Wire, pounds	—	25
Carborundum Grinding Wheel,	1	37
Saw Set for hand saws	1	
Saw Tool for two-man saws	1	
Saw Files with container	6	
Container for nails and edge tools	—	30
Explosives and other requisites, pounds	—	164
Total,		2,765

A *cavalry division* differs from that of the infantry by having horse artillery, mounted engineers, and cavalry regiments instead of infantry. Its strength is 10,969 officers and men, 12,133 animals, 24 guns, 453 wagons, and 24 machine guns. It occupies 11 miles of road on the march, and has the advantage over the infantry of greatly increased mobility.

A *field army* is the proper command of a *lieutenant-general,* which rank is not at present authorized in the U. S. Army. It would comprise two or more infantry divisions, one or more cavalry divisions, and additional troops, namely, a regiment of heavy artillery, a regiment of mountain artillery (depending upon the nature of the country), a *ponton battalion* of engineers, and an aero squadron of signal troops. There are also required additional transportation, officers, enlisted men, and civilian clerks.

The mobilization, equipment, transportation and supply of such a force is a task that calls for organizing ability of the highest order. Each commander holds his subordinates responsible, not only for the actions of their commands, but for their proper instruction, discipline and all that pertains to their efficiency. He, in turn, is responsible to his superiors for the state of his own command. Duties devolving upon an officer may be assigned by him to subordinates, but his responsibility for the proper performance of this duty does not cease. Responsibility cannot be transferred.

Upon the company commander probably falls the greatest burden, as he comes into direct contact with the men, and is subject to all the annoyances of keeping them in order and in a state of efficiency. He is charged with the preparation of the raw material, as well as its effective use in the field.

The lieutenants are his main reliance in carrying on the work of instruction. They drill the company,

hold schools for the men and non-commissioned officers, inspect equipment and quarters, take the company at routine formations, and try in every way to assist the captain and leave him free for the administrative work. Every lieutenant should be capable of commanding the company, not only as a precaution against the absence of the captain, but in way of preparedness for war, when our forces will be greatly expanded, and many officers of existing organizations will be detailed to higher commands.

The major is relieved of many of the details and routine work that annoy a company commander, but he has additional responsibilities which probably outweigh the advantages of his position. His is the smallest command which will operate independently in the field, and questions of supply, field orders and the administration of his battalion will more than occupy his mind.

And so on as one goes higher. At each step the commander is freed from some of the detail, but his responsibilities are commensurately increased.

V.

MILITARY ADMINISTRATION.

Administration is army government. It is, however, usually considered as separate from the actual work of disciplining and training an organization. The term administration, therefore, may be said to include the items of money accountability, property accountability, supply, company books and records and correspondence. This classification, while not complete, will facilitate explanation of the duties of a company commander.

Money Accountability. A company officer of volunteer engineers is not likely to become a disbursing officer, nor to be charged with the custody of public funds. However, a few rules as to the handling of financial accounts of a minor character will not be amiss.

A safe rule is that no property is to be purchased nor funds expended without the sanction of higher authority, usually the Adjutant General of the Department, to whom application must be made through military channels. A citation of this authority must accompany the voucher when presented for payment.

Except in case of emergency, or to provide food for his men when traveling under orders, an officer should not make cash purchases of supplies or material, expecting reimbursement later. The person from whom such material was purchased must submit a voucher (a creditor's claim for payment), in duplicate, upon the face of which the purchasing officer certifies that the articles were received or services rendered as specified. The voucher is then forwarded to the disbursing officer for payment. The voucher must bear the following certificate signed by the creditor:

"I certify that the above account is correct and just, and that payment therefor has not been received."

JOHN DOE.

Only the original and not the duplicate is thus certified. An officer should provide himself with the proper blank voucher forms for use in such transactions.

When expenses are incurred in traveling or in an emergency, a voucher must be submitted for the proper mileage in case of travel, or for the items of expenditure in case of reimbursement. Receipts for all items must accompany vouchers for reimbursement and travel orders must be attached to mileage vouchers. The officer must certify, as payee, that the travel was performed as per the attached order and was necessary in the military service.

An officer assigned to any duty which may involve financial accountability must familiarize himself with the Army Regulations as pertaining to disbursements.

Property Accountability. All public property is of two classes: expendable and non-expendable.

Expendable supplies are those which are consumed, as fuel, forage and rations; those which are used in works, as spikes, wire, bolts and sand bags; and those which are frequently broken or worn out in use, as tent pins and axe handles.

Non-expendable property consists of tentage, arms, equipment, tools, etc. Such articles, when worn out, cannot be thrown away, but must be submitted for the action of an inspector appointed for this purpose. If found unserviceable the property is condemned by him and destroyed in his presence, and the *accountable officer* is relieved of accountability therefor, upon the inspector's certificate, approved by higher authority.

When property is lost or damaged through other than fair wear and tear in the service, the accountable officer *at once* makes application to higher authority

for a *Board of Survey,* which may consist of one or more disinterested officers. This Board investigates the causes of loss or damage, examines witnesses, and endeavors to fix the responsibility. Upon its recommendation, approved by higher authority, the accountable officer may be relieved, or held for the value of the property, in which latter case the *responsible officer* must reimburse the Government for the amount of the loss or damage as fixed by the Board of Survey. An accountable officer not satisfied with the findings of a Board of Survey may appeal to the Department Commander, whose action is final.

All property is obtained by *issue* upon *requisition.* A requisition is a statement of property required and the use to which it will be put. It must be submitted on the prescribed forms and must bear a certificate to the effect that the property is necessary in the military service. The issuing officer, at the arsenal or depot, invoices the property to the organization supply officer, who must receipt for it and account for each item upon periodical *returns,* which are complete statements of the property on hand at the date of the previous return, that received during the period, that disposed of during the period, and the amount on hand. An accountable officer may, upon *memorandum receipt,* issue property to another officer, who thus becomes *responsible* for the property so issued. He renders no returns, but must produce the property upon demand. An accountable officer, therefore, is also the responsible officer only when the property is actually in his possession.

Accountability for expendable supplies is terminated by the receipt of the officer to whom they are issued for use, or in some cases, by certificate of expenditure.

Property pertaining to one bureau must be accounted for on the return to the chief of that bureau. For instance, property issued by the Engineer Depart-

ment must not be taken up on Quartermaster or Ordnance returns.

In general orders of the War Department, accessible at every army post, are published lists of property which constitute the authorized equipment of each organization. A booklet published by the War Department, entitled "Engineer Unit Accountability Equipment Manual," contains complete information as to Engineer equipment.

Supply. The question of supply, as it pertains to the company in the field, is merely a matter of drawing forage, clothing and rations from the nearest quartermaster. It is a well-known fact that many volunteers at the Spanish War mobilization camps went hungry simply because their commanders did not know how to draw rations.

Form I illustrates the ration return used by the U. S. Army. Orders are usually issued from headquarters as to the period for which rations are to be drawn. The first return submitted, therefore, shows the strength of the command and the number of days, which include the limiting dates. Thus Sept. 1-5 indicates a five-day period. For a company of 164 men, therefore, $5 \times 164 = 820$ rations are required.

Q. M. C. FORM NO. 261.
Authorized March 6, 1908.

No. ....
[QUARTERMASTER'S NUMBER]

Ration Return of Co. H, 2nd Engrs, U.S.V.
At Camp Columbia, N.Y., from June 6, 1917, to June 10, 1917.
No. of days 5, persons present 165, No. of rations 825.
Additions 6, deductions 20, net corrections -14

NUMBER RATIONS REQUIRED	GARRISON.	FIELD.	HAVERSACK.	TRAVEL.	FILIPINO.	
	—	✓	—	—	—	TOTAL 811

No. emergency rations required —

Other issues required, quantities actually required within regulation allowance: (No. of animals 44)

SOAP.	CANDLES, ISSUE.	CANDLES, LANTERN.	MATCHES.	TOILET PAPER.	SALT, ROCK.	VINEGAR FOR ANIMALS	FLOUR FOR PASTE.	TOWELS, HUCK.	ICE
LBS.	LBS.	LBS.	BOXES.	PKGS.	LBS.	GALS.	LBS.	NO.	LBS.

(OVER)

FORM I. RATION RETURN—FACE

THIS CERTIFICATE AND APPROVAL COVER THE ISSUES INDICATED ON THE REVERSE SIDE HEREOF.

I Certify that this Ration Return is correct and that the last regular issue of rations was made by Lt-Col. Richard C. Blank, Quartermaster at Camp Columbia, N.Y., to include date of June 5, 1917, that the emergency rations entered (if any) are required for the enlisted men of my command, and the money value of all previously drawn and improperly opened or lost has been charged against the persons responsible; that the civil employees for whom rations are required (if any) are entitled thereto under the regulations, and that the articles, other than rations, above requested are necessary for the public service.

John J. Jones

~~In charge of~~ *Commanding* Co. H, 2nd Engineers, U.S.V.

Approved and ordered issued. The total rations required agree with the morning reports, and the quantities of other articles ordered issued are necessary in the public service and within the regulation allowance.

____

____________________*Commanding.*

This form may be used for a Brigade, Regiment, Battalion, Company, Troop, or Battery, a Detachment, Civil Employees, etc.
Not to be signed in duplicate.

FORM I. RATION RETURN—BACK

Let us suppose that on Sept. 2d, after rations have been drawn for the five days, five men report sick and are sent to the hospital. They leave after breakfast, so take *two* meals at the hospital, which thus receives credit for their rations on this date. The company has therefore drawn $6 \times 4 = 20$ rations too many for the five-day period. But on Sept. 4th, before supper, six men from a signal detachment are assigned to the company for rations. They have one meal on the 4th, for which the company receives no credit, but they are charged with a full ration on the 5th. On the 6th, rations are drawn for the period Sept. 6-10. The five men are still in the hospital, and the signalmen are still attached, so the ration strength of the company is $164 - 5 + 6 = 165$, which, multiplied by the number of days for which drawing rations, gives $165 \times 5 = 825$ rations.

	825	
Additions....	6	(Six signalmen, one day.)
	831	
Deductions...	20	(Five men in hospital, 4 days.)
	811=Total rations required.	

The quantities which may be drawn of ice, candles, and other supplies shown at the bottom of the ration return are listed in the Subsistence Manual.

A detachment in the field, losing track of its own organization, may report to the nearest command for rations. Their own command carries a deduction or *minus,* during their absence, and the organization with which they mess carries a *plus,* or addition, during their presence. Many a volunteer has gone supperless to bed through lack of knowledge of this provision.

The clothing and equipment required by the individual soldier is listed in general orders, which also give the bureau by which these articles are issued. Each soldier upon enlisting draws a complete outfit of clothing, not to exceed in value the amount of his *initial allowance.* He also has a *running allowance* of so much per day, which is supposed to provide for renewals. Clothing required in excess of these allowances may be drawn by the soldier, but the excess cost is stopped out of his pay when his accounts are balanced at stated periods. Any unexpended clothing allowance may be drawn in cash upon his discharge from the service.

The captain is responsible for the proper outfitting of his command, and he is specifically charged with personal supervision over the fit of his men's shoes.

Clothing drawn by a soldier is marked by his name, and becomes his personal property, but it cannot be sold. Severe penalties are visited upon both seller and buyer in such a transaction, even when the latter is a civilian.

Company Books and Records. The principal report rendered by a company commander is one showing the state of the command and the status of each man. This is known as the *Morning Report,* and must be submitted daily. It consists of two blank pages, on the first of which is entered under each date the number of officers and men of each grade present for duty, present

on extra duty, special duty, sick in quarters, and in arrest or confinement. There is also entered the total number absent, and the aggregate strength of the command. Any man drawing rations with the company is carried as present, otherwise as absent. Thus men absent without leave, with leave (on pass or furlough) on detached service, sick in hospital, or in confinement where prisoners are not rationed with their commands, are carried as absent.

On opposite page are entered the *changes only*. Thus on the 18th (Form II below), Private Sweeney is still absent without leave and Corporal Kelly is still absent

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MORNING REPORTS

OF

Company H, 2nd Engineers, U.S.V.
(Organization)

FOR THE MONTH OF

September, 1917

FORM II. MORNING REPORTS—COVER

Day of the month	Station	C.O.—Commissioned Officers. E.M.—Enlisted Men	Present, For duty: Captains	First Lieutenants	Second Lieutenants	First Sergeants	Q.M. and Stable Sergeants	Sergeants*	Corporals and Lance Corporals	Cooks	Mechanics*	Musicians and Trumpeters, etc.	Privates*	Recruits	On extra duty	On special duty	Sick	In arrest or confinement	Absent	Present and absent	Aggregate	Signature of commanding officer
16		C.O.	1	2	1															4		
	Camp Columbia N.Y.	E.M.				1	1	12	18	2		2	128							164	168	John A. Jones
17		C.O.	1	2	1															4		
	Camp Columbia N.Y.	E.M.				1	1	12	17	2		2	127						2	164	168	John A. Jones
18		C.O.	1	2	1															4		
	Camp Columbia N.Y.	E.M.				1	1	12	17	2		2	127						2	164	168	John A. Jones
19		C.O.	1	2	1															4		
	Camp Columbia N.Y.	E.M.				1	1	11	17	2		2	121					1	8	164	168	John A. Jones
20		C.O.	1	2	1															4		
	Camp Columbia N.Y.	E.M.				1	1	10	17	2		2	122	1				3	5	164	168	John A. Jones

* Chief mechanics, mechanics, farriers and blacksmiths, wagoners, saddlers and artificers will be reported under the heading "Mechanics." Sergeants, first class, will be reported under the heading "Sergeants;" privates, first and second class, under the heading "Privates."

(10)

FORM II. MORNING REPORTS—LEFT-HAND PAGE

Day of month.	REMARKS.	
16	No remarks	
17	1st Cl. Pvt. Sweeney, D to A.W.L. Corpl. Kelly D to A.W.L.	-8
18	No changes	
19	2nd Cl. Pvts. Casey, Mosely and Schmidt D to A.W.L. 1st Cl. Pvt. Murphy D to sick in hosp. Serg't Myers, 1st Cl. Pvts. Jones and Hughes D to D.S. in field. Pvt. Lane D to conf. 1st Cl. Pvt. Sweeney A.W.L. to D.	+2 -14
20	Serg't Fuller lost by hon. disch. 2nd Cl. Pvts. Casey, Mosely and Schmidt A.W.L. to conf. 2nd Cl. Pvt. Lane conf. to D. Recruit Hendricks assigned from recruit depot	+4 -1
	Total	+6 -23

(11)

FORM II. MORNING REPORTS—RIGHT-HAND PAGE

with leave, so there is no change in the status of the company, and no remarks are necessary. Rations are here supposed to have been drawn for five days, September 16-20, for the full enlisted strength of the command, 164 (officers not rationed). Hence two men are absent for four days and $2 \times 4 = 8$ rations must be deducted from the next ration return.

On the 19th, seven men go absent, as indicated, three without leave, one to the hospital, and three upon detached service in the field. One man is placed in confinement, but rationed with the company. The deductions for the two days, September 19-20, are therefore $2 \times 7 = 14$ rations. Private Sweeney returns from absence without leave to duty, and for the two days there is an addition of two rations.

On the 20th, one man is discharged. Deduction, one ration. Three men return from absence without leave and one enlists. Additions, 4 rations. Total deductions, 23; total additions, 6. Strength at beginning of next period, September 21-25, 160 (4 officers not rationed and 4 men absent. Rations required for next period $(5 \times 160) + 6 - 23 = 783$.

In the back of the Morning Report is space for a chronological record of general events.

Unless the morning report and ration return of a company are correctly kept and check one another, the men are likely to fare badly.

Each morning, at "First Sergeant's Call," the first sergeant proceeds to next superior headquarters and turns in his morning report, previously signed by the company commander. Ration returns, on the days when due, are also turned in to these headquarters to be approved and forwarded to the supply officer.

The sergeant-major of the battalion or regiment prepares from the company reports a Consolidated Morning Report, showing the state of the entire command.

At "Issue Call," the company quartermaster sergeant, accompanied by enough help to carry back the rations, proceeds to the storehouse and receives the rations for his company, receipting therefor to the post or regimental quartermaster sergeant. Rations will probably be issued for only one or two days of the period for which a return was submitted, as there are better facilities at the store-house for keeping provisions.

In garrison or permanent camp, a company may *save* on their ration allowance, drawing the unexpended balance in cash, which thus forms the basis of the *company fund.* This fund is also augmented by dividends from the *Post Exchange,* or store, in which the company may own stock, and from the post bakery, as savings on bread materials.

The *Sick Report* is made out only when necessary. At "Sick Call" in the morning, the men who are ailing report, and an entry is made for each, showing the date, the man's name and grade, the time of reporting sick, and whether in the captain's judgment the sickness is in *line of duty,* i. e., due to natural causes occurring in the ordinary performance of duty, or *not in line of duty,* due to the carelessness, neglect or misconduct of the soldier. The men are then sent to the surgeon, who examines them and marks after their names *duty, light*

duty, quarters, or *hospital,* as the case may demand. He also enters a remark as to whether the sickness or injury was in line of duty. His judgment in this matter supersedes and may reverse that of the captain.

The proper classification of the disability, whether or not in line of duty, is of importance as affecting any claim that may be made later for a pension.

The *Duty Roster* is a list of the men in the company liable for any particular duty, usually for guard. A separate roster must be kept for each grade, sergeants, corporals, and privates. The first sergeant is notified each day as to the number of non-commissioned officers and privates that will be required for guard the following day. The roster shows the last similar duty performed by each man, and those longest off duty are detailed.

The *Order File* is a file of all orders received or issued by the company, including General Orders of the War Department, Post, and Regiment or Battalion, and such Special Orders as affect the company or refer to its personnel.

General Orders are such as affect the entire command of the officer issuing them. For example, the following is a general order:

Headquarters 2nd Engineers, U. S. V.

Camp Columbia, N. Y., Sept. 18, 1917.

General Orders,
No. 14.

1. This command will form to-morrow, Sept. 19, 1917, at 8:00 A. M., in service uniform with field equipment, for inspection by the commanding officer.

By command of Col. Jones,

Henry C. Ross,

Capt., 2nd Engrs., U. S. V.,
Adjutant.

The following is a special order:

Headquarters 2nd Engineers, U. S. V.
Camp Columbia, N. Y., Sept. 20, 1917.

1. 1st Class Private William Roberts, Company H. 2nd Engineers, U. S. V., is detailed as headquarters clerk and will report to the adjutant for duty.

By command of Col. Jones,
Henry C. Ross,
Capt., 2nd Engrs., U. S. V.
Adjutant.

The *Company Fund Book* shows all receipts into and expenditures from the company fund.

The *Company Small Arms Practice Record* is a loose-leaf book or a card file containing the record practice and qualifications for each soldier in small arms firing.

The *Descriptive List* is a small pamphlet of twelve pages, of the size of a folded letter, and containing blank spaces for his complete description, military record, including previous service, service as non-commissioned officer, markmanship, horsemanship, battles, wounds, convictions by court-martial, etc., and for his accounts, including deposits with the paymaster, clothing drawn, and a record of final settlements at discharge. When a soldier is transferred to another organization or post, even if temporarily, his descriptive list accompanies him.

The *Correspondence Book* and *Document File* will be considered under the head of

Correspondence. The specimen letter (Form III, below) shows the correct form for a military communication. On the upper fold of the letter is written the place and the date, and the words

COMPANY "D"
CORPS OF ENGINEERS, N. G. N. Y
168TH ST AND FORT WASHINGTON AVE

NEW YORK CITY, Sept. 11, 1916.

FROM - Commanding Officer, Co. D, 22nd Corps of Engineers, N. G. N. Y.
TO:- Commanding Officer, 22nd Corps of Engineers, N. G. N. Y.
SUBJECT:- Mustering Private Henry, Co. D, with Co. J.

1. Permission is requested to muster Private John C. Henry, of this company, with Company J, 22nd C. of E., on Sept. 25, 1916.

2. Private Henry was absent on the night of Sept. 4, 1916, and could not be mustered with this organization.

John Doe
Captain, Corps of Engineers, N. G. N. Y.

1st Ind.
Hdqrs 22nd C. of E., Sept. 15, 1916 - to C. O., Co D.

1. Returned by direction of Col. Smith.
2. Information is requested as to the reason for Private Henry's absence from the muster of his company on Sept. 4, 1916.

Richard Roe
Capt. Corps of Engrs, N. G. N. Y.,
Adjutant.

2nd Ind.
Co D, 22nd C of E., Sept. 18, 1916 - to C. O., 22nd C. of E.

1 Returned.
2. Private Henry's absence on Sept. 4, 1916 was due to an injury to his foot, caused by his dropping a heavy casting upon it in the shop where he is employed.
3. Private Henry was, from Sept. 1 - 10, 1916, under the care of a physician, whose certificate is inclosed.

J D
(1 Incl.) Capt., C. of E., Cmdg. Co. D.

3rd Ind.
Hdqrs 22nd C. of E., Sept. 18, 1916 - to C. O., Co. D.
1. Approved.
2. The return of this paper is requested. By direction of Col. Smith.

R R
Capt., C. of E., Adjt.

(Second Sheet)

4th Ind.
Co. D, 22nd C. of E., Sept. 20, 1916 - to C. O., 22nd C. of E.

1. Returned.
2. Noted.

J D
Capt. C. of E., Cmdg. Co. D

(Rubber Stamp)
Rec'd back Hdqrs 22nd C of E 9-20-1916.

FORM III. MILITARY COMMUNICATION

"From," "To," and *"Subject."* In filling out a heading, designations of officers rather than their names, should be used, thus: *From:* Commanding Officer, Co. H, 2nd Engineers, U. S. V.

If a letter is to go higher than the next superior headquarters, it is addressed to the officer who will take action, adding under his name "(Through Military Channels)" and sent to the next superior headquarters to be forwarded.

The subject should not contain more than ten words, and no letter must refer to more than one subject.

The heading as indicated, and *nothing else,* must occupy the top fold.

The body of the letter follows, without salutation, the paragraphs numbered, and a margin of one inch at the left. If written upon a typewriter, paragraphs are single spaced, and separated by a double space. The signature follows the body of the letter *without closing expressions,* such as "Yours respectfully." If the grade and position of an officer are given in the heading, they are not repeated in the signature.

Indorsements follow the signature in order, numbered consecutively. They must indicate the organization by whom sent, the headquarters or officer addressed, and, if transmitting indorsements only, may simply contain the word "Forwarded" in their body.

It is customary in replying to a letter to return the original by indorsement, instead of writing a second letter. If inclosures are sent, their number is indicated at the left of the letter, opposite the signature.

Two carbon copies of a letter are made, one of which is retained by the sending officer, the other, signed by initials only, or by a typewritten signature, is forwarded with the letter. This is for the files of the receiving officer if the letter is returned by indorsement or forwarded to a higher headquarters. Press copies are no longer used.

In mailing, the top fold is folded *back,* and the bottom fold *up,* covering the body of the letter. The top fold, with the heading, is therefore left on the outside of the folded letter, taking the place of the former briefing.

In the *Correspondence Book* is kept a record of the writer of each letter sent or received, the person or office addressed, the date forwarded, a brief of the contents, and a record of the action taken. The form letter shown would have the following entry:

> 53
> C. O. Co. D, 22nd C. of E., N. G. N. Y.
> to C. O. 22nd C. of E., 9-11-16.
> Requests permission to muster Pvt.
> Henry with Company J, 9-25-16.
> Rec'd back 9-18-16.
> To C. O. 22nd C. of E., 9-18-16.
> Rec'd back 9-21-16, Approved.
> Noted and returned.

This would be cross-indexed under the headings *muster* and *Henry.* A copy of the letter is numbered serially to correspond with number of the entry in the Correspondence Book, the indorsements relating to the action taken are copied upon it, and the copy is filed in the *Document File.*

VI.

ENGINEER TROOPS IN THE FIELD.

DUTIES.

According to the Official Bulletin of the General Staff, U. S. Army, Vol. I, No. 4, December, 1914, the duty of engineer troops in the field is to apply engineering science to the emergencies of modern warfare in order to protect and assist troops, to ameliorate the conditions under which they are serving, to facilitate locomotion and communication, and whenever the occasion requires to act as purely combatant troops.

Captain Thomas M. Robins, Corps of Engineers, U. S. Army, in his lecture to the United Engineering Societies upon "Organization and Duties of Engineers in War" used the following apt comparison: "An army in the field is a machine which may be worn out and rendered unserviceable by interior as well as exterior friction. It is the duty of the engineer to lubricate this machine and at the same time to throw sledge hammers into the gears and cogs of the enemy's machine, to prevent its working as he wishes."

In the performance of these duties engineers are trained and equipped to supplement or amplify by scientific measures the efforts of combatant troops in the services enumerated below and such other special services of an engineering nature as may arise and are beyond the technical training of combatant troops, or such as require the use of engineering implements and material not supplied to combatant troops.

Scope of Services.

(a) The service of reconnaissance, including tactical reconnaissance, engineering reconnaissance, surveying, mapping, and sketching, panoramic sketching, photography, drafting, and map reproduction.

(b) The service of castramentation, including the selection, laying out and preparation of camps, the reconnaissance and municipal and sanitary engineering incident thereto, and the installation, operation and maintenance of water-supply systems.

(c) The service of fortifications, pertaining both to the attack and the defense and including the selection of defensive positions when out of the presence of the enemy; rectification of and assistance in the selection of such positions in the presence of the enemy; the location, design and construction of the more important field works; assistance in and supervision of the construction of hasty defenses wherever possible; the supply of tools and materials; and the reconnaissance, demolitions, water-supply and communications incident thereto.

(d) The service of sieges, pertaining both to the attack and defense and including the selection and location of defensive lines, lines of investment and siege works, the construction of saps, mines and countermines; the operation of search-lights; preparation for and assistance in attacks, counter attacks and sorties; organization of captured points; and the supply of tools and materials.

(e) The service of demolitions, including the carrying out of all work of this nature authorized by the commander and not within the scope of other troops.

(f) The service of battlefield illumination, including the supply and operation of search-lights and other means of battlefield illumination.

(g) The service of general construction, including the location, design and construction of wharves, piers, landings, storehouses, hospitals and other structures of general utility in the theater of operations.

(h) The service of communications, including the construction, maintenance and repair of roads, ferries, bridges and incidental structures; the selection and

preparation of fords; the construction, maintenance and operation of railways under military control, and the construction and operation of armored trains.

(i) Special services, including all municipal, sanitary and other public work of an engineering nature which may be required in territory under military control.

The services in the above list are executed under the supervision of engineer officers by engineer troops, by details from other troops, by civilian labor or by any combination of these means as the particular circumstances may require.

Time is usually all important and labor is plentiful, and wherever the labor of other troops can be profitably used such troops should be provided promptly and used freely, the tools of the engineer train being brought up for this purpose.

ORGANIZATION.

The engineer troops and equipment of a division consist of a battalion of pioneers, an engineer train and such proportion of the ponton battalion as may be assigned to the division.

An infantry division is the largest complete tactical unit in our army. It is made up of forces from all arms of the service excepting coast artillery.

The pioneer and ponton battalions are organized alike, and contain approximately 500 men each, so that they form about three per cent. of the total forces, which proportion is very small as compared with other armies, and will undoubtedly have to be doubled.

The proposed reorganization of the army contemplates engineer regiments of two battalions (six companies), about 1,000 men, one such regiment to be attached to each division. The resulting proportion of engineers to combatant troops would be 6 per cent., which agrees very well with foreign practice.

An engineer company consists of 4 officers, mounted, and 164 enlisted men, of whom 24 are mounted.

The organization is as follows:

1	captain,	mounted
2	first lieutenants,	mounted
1	second lieutenant,	mounted
1	first sergeant	
1	quartermaster sergeant	
12	sergeants,	2 mounted
18	corporals,	3 mounted
2	cooks,	1 mounted
2	musicians	
64	privates, 1st class,	18 mounted
64	privates, 2d class	on mules

Only a small number of men from each company are trained for photography, surveying, drafting, demolitions, operation of engines, etc., but practically all of the company are trained for all such work as roads, fortifications, bridges and mining.

EQUIPMENT.

The following is the combat train of each company:

Two wagons containing instruments, tools, tackle, explosives and supplies. (Mainly for the foot troops of the company.) Practically identical loads on each.

Eight pack mules, with two demolition packs, three packs of tools, tackle and supplies, and three packs of grain, rations, additional tools or explosives. (Mainly for the mounted detachment of the company.) It will be observed that each company is so organized and equipped that it can provide the following working parties:

(a) The small parties necessary for demolitions, sketching, mapping, etc.

(b) A mounted detachment, especially provided for work at a distance from the foot portion of the company.

(c) Two almost identical foot detachments of from 50 to 65 men. In addition to the equipment carried in the combat trains of the companies there is the following equipment:

(a) Battalion combat train—

1 wagon (surveying, drafting, photographic and reconnaissance equipment.)

1 wagon (blacksmith and map reproduction equipment).

(b) The Engineer Train, 9 wagons (reserve entrenching tools for infantry), carrying the following equipment.

234	Axes	117	Hand Saws
63	Crowbars	117	Saws, 1 or 2 man
900	lbs. Nails	2700	Shovels
1350	Pick Mattocks	225	lbs. Wire, smooth
4050	Sand Bags		Tool sharpeners, etc.

(c) The bridge equipage with the Field Army, consisting of 6 divisions (1350 feet) of the heavy equipage and 3 divisions (558 feet) of the light equipage. Divisional engineer troops assist in handling the equipage assigned to the division. Whenever a division is in action alone in the field at least one division of bridge equipage should be assigned to it.

DETAILED DUTIES.

On the March, engineer troops verify, correct, and amplify existing maps or prepare and reproduce road sketches in the absence of other maps. They examine routes and local resources with a view to their utilization. They mark roads and furnish guides when necessary. In an advance they remove obstacles, and in a retreat they place obstacles to check the advance of the enemy. They execute demolitions, especially in a retreat, and destroy materials, stores, and natural resources whenever so ordered. They prepare roads, bridges, fords, and ferries, and strengthen structures,

make repairs, or build entirely new ways of communication and assist the artillery and heavy vehicles in difficult places. They prepare photographs to supplement reconnaissance and records.

The Advance. Regardless of the character of the march, delays are always to be expected either from the enemy and his activities or from bad roads, accidents to road structures, or from some other cause, and the troops, to make the way clear and expedite the march, ought, unless other considerations forbid, to be near the head of the column to attack the obstruction as soon as it is discovered and obviate the delay incident to bringing them and their combat train up from the rear along a road encumbered with other troops and vehicles. Therefore a working unit of engineers, preferably a company, should be at the head of the column and should form a part of the support of the advance guard.

The Retreat. In a retreat there is always the presumption of a pursuit by the enemy, and the disposition of the engineers might well be about as follows for a division marching on a single road:

Battalion (less 2 companies), ahead of the trains.

1 company, at the head of the leading troops.

1 company, as part of the rear guard.

This disposition is merely a suggestion and not a type formation.

The duty of the first body is to insure that the road is open and the way clear and that of the second to see that these conditions are maintained. The duty of the third, in addition to assisting in the conduct of the retreat, is to delay the advance of the pursuing force by placing obstructions along the route or routes and by actual combat when necessary. The main part of this company will be with the reserve of the rear guard and will *prepare* bridges, etc., for demolition. The mounted detachment will be with but ordinarily will

not form a part of the rear cavalry. Their function is to make the demolitions after all the troops have passed, and then by means of their mounts rejoin the rear party and repeat the operation. If the road is to be obstructed by fallen trees and other such obstacles, the main part of this company may fall farther to the rear than above indicated.

The Attack. In the attack, the engineers reconnoiter for and facilitate the advance of the other troops by repairing and constructing roads, bridges, and ferries, improving fords, and making clearings to facilitate communication and deployment. Engineer troops accompany the attacking line for the purpose of destroying and clearing away obstacles, destroying hostile mines, organizing captured positions, and for destroying guns, works, and stores which can not be held. They assist in clearing the field of fire for the artillery and in arranging for observation of fire, including the construction of high observing stations. They destroy or blockade ways of communication to guard against flank attacks. They supply tools to troops taking up a position in a deliberate attack and assist in the preparation of fortified portions of the line. They are specially concerned with the construction of supporting points to check temporary reverses, works to guard against counter attack on the flanks, and works of general interest, such as dressing stations, ways of communication, and the like. They give assistance to the artillery for the advance preparation of new positions, so that the artillery may move from one position to another with the least loss of time. They operate searchlights or other means of illumination used in night attacks; they mark roads and trails leading along the positions, and, if necessary, supply guides; they make the engineer reconnaissance to locate and procure tools and materials and otherwise utilize available local resources to the fullest extent; they will make

and reproduce such position and place sketches, photographic views and panoramic sketches of hostile lines as may be practicable. Engineer troops will be used on the firing line whenever it is desirable to bring all available rifles into action, or when their position is such that they can render the most effective service by fire action.

The combat train advances with the companies as far and as rapidly as possible, so that tools and supplies shall always be near at hand; but they should be halted off the road when they can no longer advance and should never be allowed to delay the advance of the troops.

If the attack encounter fortified positions, the engineers are used in the firing line to destroy obstacles or mines, to handle grenades, to accompany and assist the brigade commander in reconnaissance of the hostile position, and assist in organizing captured positions against counter attacks.

The strength of the enemy's fortifications will determine the rate of advance, and the slower the advance the greater will become the usefulness of the engineer troops. The operation of searchlights and other means of battlefield illumination will be employed in protracted attacks, and the illumination of roads, etc., will be required.

The Defense. On the defense the engineers assist in clearing the foreground, placing obstacles, and determining and marking ranges, and are specially concerned in the construction of works of general interest, including dummy trenches, bomb proof and splinter proof overhead covers, screens, dressing stations, observation stations, and supporting points. They assist in preparing woods, houses, and villages for defense, and in repairing damaged works. They operate searchlights and other means of illumination. They destroy or blockade ways of communication and destroy stores

and other resources or structures that may be useful to the enemy and are certain to fall into his hands. They prepare land mines, fougasses, and grenades. They distribute the tools to troops taking up positions, prepare positions fortified in advance of their occupation, and supervise civilian working parties on such lines. As in the attack, they improve or construct roads and other ways of communication, including field railways, and facilitate the movement of troops and supplies throughout the entire position. They will make such sketches and reproduce such photographic views as may be practical. They make the engineer reconnaissance to locate and procure tools and materials and other local resources.

Their numbers prohibit them from doing all the clearing or all the entrenching, even if such were otherwise desirable. They assist in laying out and constructing the trenches, obstacles, overhead cover, dummy trenches, etc., and in clearing the foreground and concealing the position.

Sieges. In sieges engineer troops have the same duties as in an attack or in a defense, according to whether they are besieged or besieging. They have also the duties required of them in camps, and are specially charged with the location and construction of siege batteries, parallels, approaches, mines and countermines and obstacles. They prepare for and assist in assaults and sorties, destroy obstacles, hostile mines and works, and prepare captured positions for defense.

Prior to assaults or night attacks the ground to be passed over should be carefully reconnoitered and mapped, if practicable, and engineer officers should act as guides to the attacking troops. The columns should be accompanied by engineer troops with the necessary tools and equipment to assist the advance and to strengthen any position captured.

In Camp (not short halts or bivouacs) the engineers lay out the camp and make the necessary surveys or sketches of the camp and outpost and reproduce maps for the command. They prepare and mark the watering places and may be called upon to install the water supply. They construct the main drainage system for permanent camps and other works of sanitation requiring special skill or equipment. They assist in the construction of shelters. When the camp is fortified the engineer troops have the same duties as in a defensive position. They carry out such demolitions as may be required. They repair roads and bridges, constructing such new ones as may be required, and prepare the terminal facilities, both by rail and water, and mark the routes of communication and deployment and construct and operate portable railways. They construct buildings of general interest and such other engineering works as may be required of them. They also do such photographic work as may be required, and make special examination of the terrain with a view to engineer work and the utilization of local resources.

A single battalion can not do all the technical work in a camp as rapidly as its completion is desired, but by using the engineer troops for such work only and giving them such assistance in unskilled labor as may be required, the rapidity with which roads, drains, huts, buildings, etc., can be constructed is surprising. The ordinary guard, police, and fatigue work for the general camp and all other details not requiring technical skill nor equipment should be made from other troops and details from the engineer troops should be confined to such duties as make use of their special training and equipment. When practicable the engineer troops should be sent to the camp site well in advance of the other troops, except signal and quartermaster troops.

VII.

FIRE ACTION.

To comprehend the subject of field fortifications it is necessary to know and understand the effect of fire both from small arms and artillery, destructive forces quite different in action from those against which the engineer must ordinarily protect his works.

To shoot straight, to direct a projectile true to its intended mark, is a feat of engineering just as much as the true pointing of a theodolite in a geodetic survey, and one performed under vastly more difficult conditions: great personal danger, unknown range or windage, and no system of least squares that has yet been invented to "adjust" a wide shot after it is fired, even if the source and amount of error is known. It is the belief of many that proficiency in rifle shooting comes only with actual practice in firing, and that only men with keen eyesight and iron nerve can hope to become expert riflemen.

As a matter of fact, most riflemen of the writer's acquaintance have probably less than normal eyesight. Most of them wear glasses in shooting. It is not the eyesight, but the manner of using it which counts, and the modern holds with the sling will correct any tendency towards unsteadiness due to nerves.

Rifle Instruction. It is easy to comprehend that a man of intelligence, instructed as to reading a vernier, as to "bisecting" a target, and in the mechanism of the transit, tangent screws, etc., might make a very creditable reading of an angle at his first trial. Upon this fact is based the system of training in Company D, an intensive system by which we claim to make a good shot of a man *before he ever fires his rifle.*

Marksmanship embraces the following principles: knowledge of the rifle, of sight setting, sighting, and of holding the aim while pulling the trigger.

When a recruit joins Company D, an officer or non-commissioned officer gives him the following instruction in the rifle:

He is instructed in the data regarding the rifle, its name, length, weight, caliber, sight radius, etc., and in the correct nomenclature of the parts.

He is required to dismount the bolt and magazine mechanism repeatedly, and is instructed in the proper manner of caring for and cleaning the piece, to work always from the breech in cleaning, in order to avoid injury to the rifling at the muzzle and consequent loss of accuracy.

He is practiced in the manipulation of the rifle by loading drills with dummy cartridges, until in his hands it is no longer a source of danger to himself or "innocent bystanders."

The recruit is next shown how to use the sights. Enlarged patterns of the sights are cut from sheet brass, and mounted by hinges on a wooden bar. An additional hinged flap, containing a small pin hole, is mounted at the eye end of the bar. The pin hole is on the line of the center of the rear sight and the top of the front sight, so that in looking through it the rear and front sights always appear in perfect alignment.

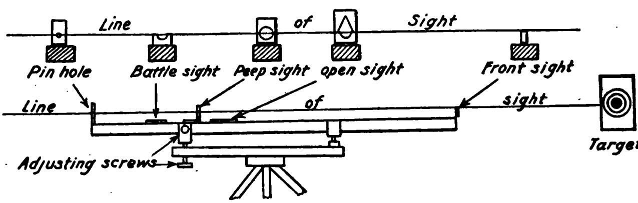


FIG. 1. BAR FOR INSTRUCTION IN THE USE OF SIGHTS

First Exercise. The instructor sets the sights, peep, open or battle-sight, on a target across the room. The

recruit, looking through the pin hole, sees the rear and front sight and the bullseye in proper alignment. The bar is then moved and he is required to reset on the target, using the adjusting screws.

Second Exercise. The pin hole flap is turned down out of the way, and the recruit is required to align the sights and bullseye, centering the front sight in the rear peep or notch as well as he can. He checks the result by turning up the rear flap and looking through the pin hole. Any error in "centering" the front sight now shows clearly. The instructor can also see the amount and direction of the error and take steps to correct it.

Third Exercise. This apparatus may also be used to illustrate the importance of fixing the eye on the target instead of on the front sight. The target is covered and the recruit directed to gaze intently at the front sight. The target is now uncovered and is seen indistinctly, as his eye is out of focus. The front and rear sights are then laid down, and his eye, looking through the pin hole, is focussed on the target. When the sights are raised, he finds that he can, still looking intently at the bullseye, see *through* and *over* the sights and tell when they are correctly aligned, *without gazing directly at them.*

The positions are then demonstrated, with explanations of the reasons for each detail, and the sling hold is illustrated and insisted upon for each man.

For instance, in the kneeling position, the weight rests on three points: the sole of the left foot, the right knee and the right toe. For steadiness, these three points must be as widely separated as possible, preferably at the vertices of an equilateral triangle, similar to a tripod. The left foot points towards the target, the heel well forward so that the leg below the knee is vertical. The right leg rests squarely across the line of fire. If the left heel is drawn back, the body

will rock backwards and forwards and the sights will move vertically on the target. If the right knee is brought close to the left heel, the right leg pointing to the rear, the body will sway from side to side, and the sights will move horizontally on the target. The left elbow, supporting the rifle, must hang over the left knee-cap. A trial at supporting the elbow on *top* of the knee will show the unsteadiness of this position.

The use of the sling is advocated as it steadies the aim, assists the "hold" while pulling the trigger, and tends to minimize the recoil.

Similar instruction is given regarding other firing positions.

He is now prepared to shoot, but in order to coordinate all that he has learned regarding the manipulation of the rifle, positions and sighting, without preliminary waste of ammunition, and to prevent developing *flinching* or *gun-shyness* from the recoil and report, there is yet another step by which he may apply all that he has learned and actually take his position, aim, hold, fire, and "call his shot," before going upon the range.

The Hollafield Rod consists of a brass tube which fits in the bore of the rifle and contains a movable plunger or needle, sharpened at the outer end. This needle, held in place by a spring, rests down upon the firing pin, which, when the trigger is pulled, drives the needle out about six inches in front of the muzzle, from which position it is immediately returned by the spring. A double target is used, the vertical distance between the bullseyes being equal to that from the tip of the front sight to the center of the bore. (Fig. 2.)

The needle will puncture the lower target at the corresponding point to that on the upper target which is covered by the sights at the instant of firing. The targets are reduced in size so as to subtend the same

visual angle at six inches in front of the muzzle as a standard target at the regulation range.

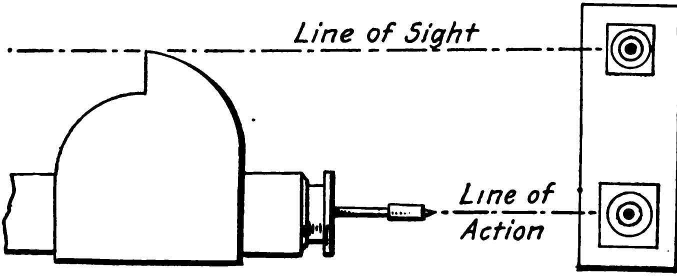


FIG. 2. THE HOLLAFIELD ROD

By using a shorter rod, and placing in the chamber of the rifle a dummy cartridge containing a movable plunger, the method of loading may be practiced. The firing pin strikes the plunger in the cartridge, which passes the blow on to the needle of the Hollafield Rod and operates it as before. These cartridges may be loaded into the rifle by clips, the same as service ammunition, and rapid or magazine fire may be simulated in all respects except as to the recoil and report.

The recruit is now ready for the range, the foregoing instruction having occupied about two or three hours, depending upon his adaptability. He is familiar with all except the recoil and the report, and on the indoor range the former is missing, owing to the reduced charges used. However, cases of flinching do occur, and are usually corrected by the instructor's loading the man's rifle for him, sometimes with an empty shell, so that he never knows in pulling the trigger whether or not the gun will go off. Flinching is caused by anticipating the report. The report itself may cause a man to jump, but it is then too late to deflect the bullet. The practice of *calling the shot,* i. e., calling

out where the shot has struck judging from the point covered by the sights at the instant of firing, will usually fix the attention and prevent shutting the eyes or flinching. Care must be taken, however, not to call the position of the sights when *beginning* the trigger pull, as this is liable to vary greatly from their position on firing.

For describing the position of hits on the target, a simple clock-face nomenclature is used. In Fig. 3, a hit at (1) is described as *a bullseye, pinwheel,* at (2), a

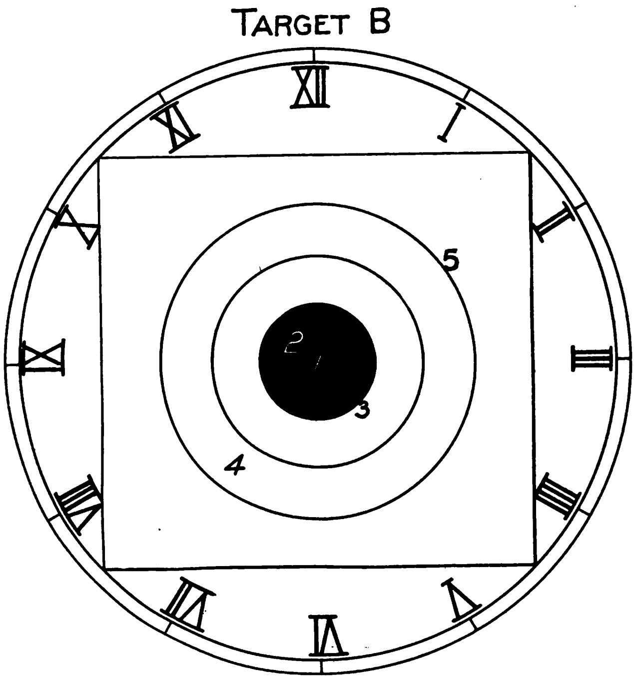


FIG. 3. TARGET NOMENCLATURE

bullseye, half in at ten o'clock, at (3), *a four, hanging on at five o'clock,* at (4) *a three half out at seven o'clock,* and at (5) *a two just out at one-thirty.*

Outdoor Firing. A similar nomenclature is adopted to describe the direction of the wind. (Fig. 4.) The clock-face is supposed to lie on the ground, the XII pointing toward the target. A head wind is a *twelve o'clock wind,* one from the right is a *three o'clock wind,* and one blowing towards the target is a *six o'clock wind.* 1, 5, 7 and 11 o'clock winds require half the correction, and 2, 4, 8 and 10 o'clock winds about the same correction, as one from 3 or 9 o'clock. A wind which changes direction continually from one

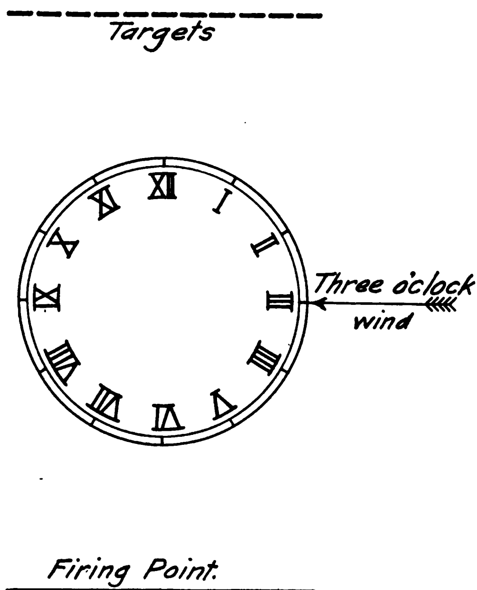


FIG. 4. WIND NOMENCLATURE

hand to another, say from 10 to 2 o'clock, as frequently happens when the targets are placed against a hill as a back-stop, is known as a *fish-tail wind.*

Outdoor firing brings into play factors hitherto unknown: wind, mirage and the varying effects of light and shade. Shooting ceases to be mechanical and becomes a matter of skill and judgment in estimating and correcting for conditions which may not be twice alike. The windage correction may vary between shots from three-quarters of a point right to the same to the left in a fish-tail wind, and the mere passing of a cloud over a target previously bright may make a difference of fifty yards in elevation at six hundred yards.

By his previous instruction and practice the recruit is supposed to have learned to aim, hold and pull correctly, and above all to have confidence in his hold, in other words to be able to *call his shot* with certainty. Unless he can do this, he cannot be sure whether a poor shot was caused by incorrect adjustment of the sights or a bad *pull.* The man who is confident that his hold should have given him a bullseye, but who gets a *three half out at five o'clock,* may change his sight setting with certainty that, conditions being the same, his next shot will strike where he aims.

Mirage, the *heat waves* that are so annoying to the surveyor, may be of great assistance to the rifleman. By focussing a telescope just short of the targets these waves may be seen running across the field like the current of a river. They give the direction of the wind, sometimes quite different from that felt at the firing point, and show sudden changes which would otherwise be unnoticed except by their effect upon the shots. From their speed, estimated in miles per hour, the *range rule,* Velocity x Range/40, gives the windage correction, to be applied against the wind, i. e., the wind gage must be moved to the right to counteract a

wind from that direction. At 600 yards, according to this rule, a 10-mile wind requires a correction of

$$\frac{10 \times 6}{40} = 1\tfrac{1}{2} \text{ points on the wind gage.}$$

One point on the wind gage subtends a horizontal distance of four inches on the target for each hundred yards of the range. At 600 yards a change of $1\frac{1}{2}$ points varies the position of the hit by $6 \times 4 \times 1\frac{1}{2} = 36$ inches. Therefore a ten-mile wind at 600 yards would be sufficient to cause a shot fired without correction to miss or just strike the edge of the target (72 x 72 inches). Fig 5 shows the correction scales, both for

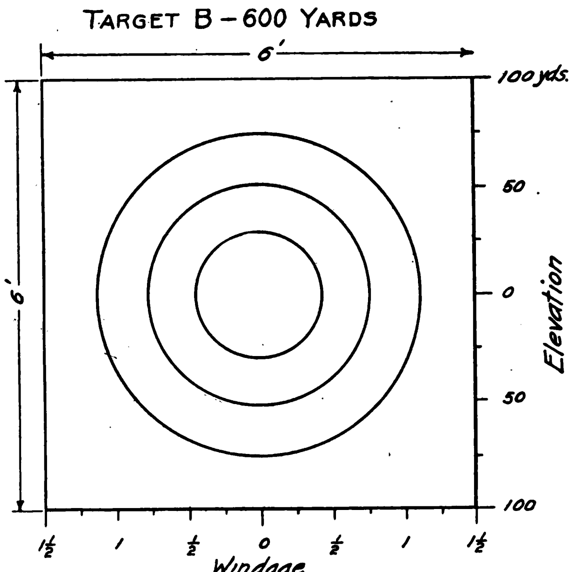


FIG. 5. CORRECTION SCALES

elevation and windage, for the B target used at 600 yards. The rule for the elevation correction is: *a change of one hundred yards in elevation will raise or lower the position of the shot by a number of inches equal to the square of the hundreds of yards in the range.* At six hundred yards, therefore, a change of 100 yards in the sight setting will change the elevation of the hit by 6 x 6 = 36 inches, half the height of the target. (Fig. 5.)

Effect of Small Arms Fire. If a number of men are firing at an object, the best shots striking it, the others missing by various margins, the whole *sheaf* of trajectories will form a cone about that of the best shot as an axis. (Fig. 6.)

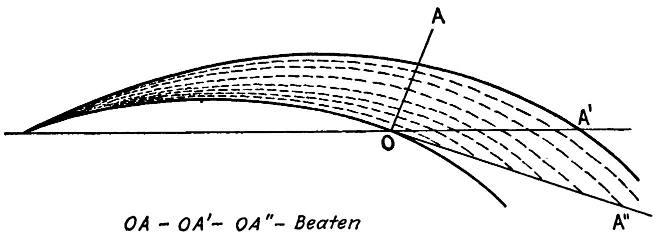


FIG. 6. CONE OF DISPERSION

This is known as the *cone of dispersion* and its intersection with the ground surface is the *beaten zone.* This cone, similarly to the stream from a fire nozzle, may be played over a field at the will of the commander by his designating the range and objective. In laying out a plan of fire action, each unit, however large or small, must be assigned its sector of fire and *kept to it.* It is natural for men to fire at what can be most clearly seen, and unless they are held strictly to a portion of the line and cover their own front thoroughly, it may happen that a section of the enemy's

line, well concealed and not troubled by hostile fire, is able to fire with deadly accuracy and inflict heavy losses.

Rifle fire which dominates a certain space and keeps the enemy from occupying it is just as effective as that which strikes his men, and the greater the space which can be thus occupied by fire action per unit volume of fire, the more efficient is that fire.

Suppose we consider a plane surface perpendicular to the axis of the cone of dispersion. The least section of a cone is the circle, perpendicular to the axis, and therefore such a slope, facing *towards* the enemy, will be less swept by his fire than a level plain. On a re-

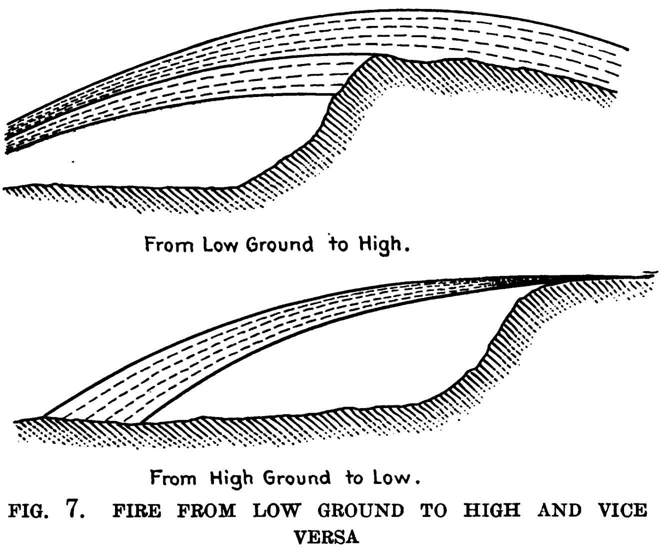


FIG. 7. FIRE FROM LOW GROUND TO HIGH AND VICE VERSA

verse slope *parallel* to the axis of the cone of dispersion the entire surface is swept by a *grazing* fire, and the whole slope is untenable without cover.

Fig. 8 illustrates the term *danger space.*

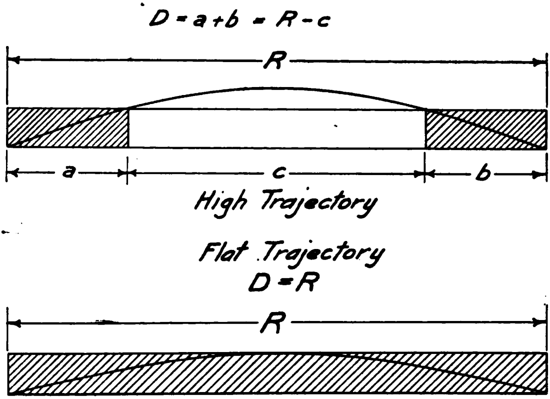


FIG. 8. DANGER SPACE

A bullet from our military rifle would be dangerous to a man standing throughout its range up to 700 yards. A slope which makes an angle with the trajectory decreases the danger space, as when firing against a hillside or from a height onto a plain, and a reverse slope, parallel to the trajectory or nearly so, permits a *grazing* fire with greatly increased danger space.

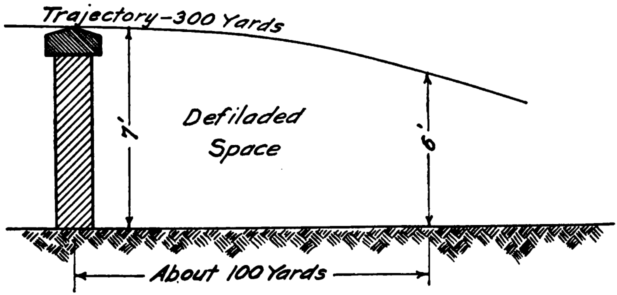


FIG. 9. DEFILADE

A *defiladed space* is one which is protected from hostile fire. A slope parallel to the trajectory increases the defiladed space formed by a given object, while a contrary slope decreases it. (Fig. 9).

PENETRATION OF RIFLE BULLET.*

Material	Maximum Penetration.	Remarks.
Steel plate, best hard.	1/16 inch	At 30 yards normal to plate, 3/16 inch req'd.
Steel plate, ordinary mild or wrought iron.	¾ inch	3/16 inch is proof at not less than 600 yards, unless the plate is set at a slope of 3 to 2, when 3/16 inch is proof at 250 yards.
Shingle	6 inches	Not larger than 1 inch ring gauge.
Coal, hard	9 inches	
Brickwork, cement mortar	9 inches	150 rounds concentrated on one spot will breach a 9-inch brick wall at 200 yards.
Brickwork, lime mortar	14 inches	
Chalk	15 inches	
Sand, confined between boards, or in sandbags	18 inches	Very high velocity bullets have less penetration in sand at short than at medium ranges.
Sand, loose	30 inches	
Hard wood—*e. g.*, oak, with grain	38 inches	
Earth, free from stones (unrammed)	40 inches	Ramming earth reduces its resisting power.
Soft wood—*e. g.*, fir, with grain	58 inches	Penetration of brickwork and timber is less at short than at medium ranges.
Clay	60 inches	Varies greatly. This is maximum for greasy clay.
Dry Turf or peat.....	80 inches	

*From British Manual of Field Engineering.

Artillery fire has grown to be a most important factor in modern tactics. With the great increase in volume and accuracy which has been developed in the present war, it bids fair to almost revolutionize battle tactics and the art of fortification. The introduction of *indirect fire* and *spotting* permits a battery to take up a position of comparative safety and systematically search out the landscape.

The battery commander, with an instrument resembling an engineer's transit, places himself where the target, the guns, and some other point visible to the gunners can be seen. The guns themselves may be separated from the target by a hill or other obstacle. The observer reads the angle between the target and the *common aiming point*. A simple computation, assisted by tables, gives the gunner the angle at which his panoramic sight must be set, so that when aiming at the common point, his gun is pointed at the target. The *angle of site,* which depends upon the difference of elevation of the gun and the target, also enters into the problem, it being clear that of two points at the same distance from the gun, the higher will necessitate a greater elevation of the gun to hit it than the former. The distance from the guns to the station and to the target is triangulated or estimated.

The *spotter* is an officer located near enough to the target to observe the effect of the fire. He is connected with the battery commander by telephone and corrects the laying of the guns by reporting the results of the shots. He also picks up points which may be of importance, for instance, a section of road which must be crossed by the enemy in charging, directs the firing of a few ranging shots, until the target is struck consistently, and causes the battery commander to register the target under a serial number or letter, together with such gun data (range, azimuth, etc.) as will enable him to again find the target without further sight-

ing shots. The spotter can at any time thereafter sweep the road in question by telephoning to the battery, "Target H, shrapnel, rapid fire".

Artillery projectiles are of two kinds: *high explosive shell* and *shrapnel.* The former apparently has no limit to its destructiveness, and no structure can long withstand it. The Russians on 203-Meter Hill found that 12 feet of earth over their bomb-proofs was insufficient protection from the shells of the Japanese 11-inch siege mortars. A projectile from a 12-inch U. S. coast-defense mortar, fired inland, has been known to penetrate 30 feet in natural compact earth before exploding. Fortunately guns of this size are few and are generally available against selected points only, and therefore would not be used for the bombardment of long lines of field-works. A parapet thickness of 12 to 15 feet of earth and overhead cover of about six feet will protect against ordinary explosive shell from field pieces, unless the bombardment be concentrated or long continued.

Shrapnel is used mainly against the *personnel* of an enemy, as is the explosive shell against his *matérial.* At a range of 3000 yards on level ground a burst of shrapnel covers an approximate ellipse about 20 yards by 150 yards, or 2350 square yards, the longer dimension lying from front to rear. (Fig. 10.) The distribution of the bullets and fragments, or *splinters,* over this area is not uniform, the end nearest the enemy receiving the greatest number. The major axis of the beaten zone decreases with a greater or a less range. It also decreases as the slope is tilted *towards* the enemy, and increases on a reverse slope, similarly to the beaten zone of rifle fire. Its width remains unchanged except as affected by the height of the burst. Shrapnel splinters and bullets cause badly lacerated wounds, but they will not penetrate a steel helmet, the pack on a man's back, nor a six-inch layer of well-

compacted earth as overhead cover. Troops well entrenched have nothing to fear from shrapnel. The angle of fall of shrapnel bullets is so steep, 18 degrees

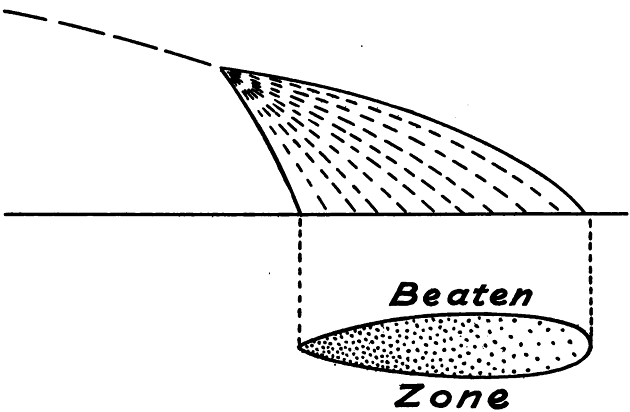


FIG. 10. A BURST OF SHRAPNEL

with the vertical, that any trench designed to resist it must be very deep and narrow, or must be provided with some form of overhead cover.

Against entrenched troops shrapnel is not effective, and high explosive shell must be used to demolish the works and get at the men. In Europe it has been found that men are killed by the back blast of a shell, without being touched by its fragments. This is guarded against by throwing up an embankment in the rear as well as in front of the trench.

CHAPTER VIII.

FIELD FORTIFICATIONS.

Fortifications are defined as "any engineering devices for increasing the fighting power of troops in the field." That which protects our troops from the enemy's fire, or simply conceals them, which assists our maneuvers and communications, or hinders and obstructs his, which is useful to us or destroys what is useful to him, will increase our fighting power. Intrenchments, screens or blinds, obstacles, communicating trenches, mines and demolitions, all come under the head of fortifications. Of these, by far the most important are those which afford protection from the enemy's fire and incidentally provide concealment and means of intercommunication. The term fortification, as usually employed, refers to works of this character only.

Field works may be considered as to:

1. Location, or siting.
2. Trace, or ground plan.
3. Construction.
4. Concealment.

LOCATION OF FIELD WORKS.

The location of trenches is affected by: first, the general line to be occupied, second, tactical considerations and features of the *terrain*.

The general line to be held is determined by the commander of the field forces, and depends upon strategical considerations. Subordinate commanders may exercise considerable latitude in the local siting of works, so long as they do not depart from the general

line, mask the fire of other organizations, nor introduce dangerous salients or re-entrant angles into the line.

Troops who will occupy a line of trenches, therefore, endeavor to fit them to the terrain, so as to provide concealment, reduce the work of construction, or to augment the effectiveness of the works. Tactical considerations, such as actual or potential interference by the enemy with the construction, may affect the location.

Works for the defense of a position should provide concealment, a clear field of fire to the front, good communications to the rear, and the flanks must be made secure, either by resting upon some natural obstacle, as a river, swamp, cliff, etc., by contact with adjacent troops, or by proper construction. A clear field of fire to the front was formerly considered all important, to be secured, if necessary, at the expense of all other considerations. With the greatly increased effectiveness of modern artillery, however, it has been accepted as a general maxim that "that which is seen is as good as destroyed," and concealment of the works becomes of prime importance. Improvement of small arms, machine guns, and the wire entanglement render more certain the stopping of an attack in the final 100 yards. In this portion of the immediate foreground, therefore, it is important that no part be screened from the fire of the defense by vegetation, buildings, or topographical features. Vegetation and buildings may be cleared away, gullies and hollows filled and slopes pared down, but much of this labor may be avoided by proper selection of a site. In Fig. 11, a position at the military crest, B, commands *all* the foreground, while one at the topographical crest, A, leaves considerable *dead space,* where the enemy may collect in safety and rest for a final dash up the hill. Furthermore, the latter position brings the works

into relief against the sky, where they are plainly visible to the enemy.

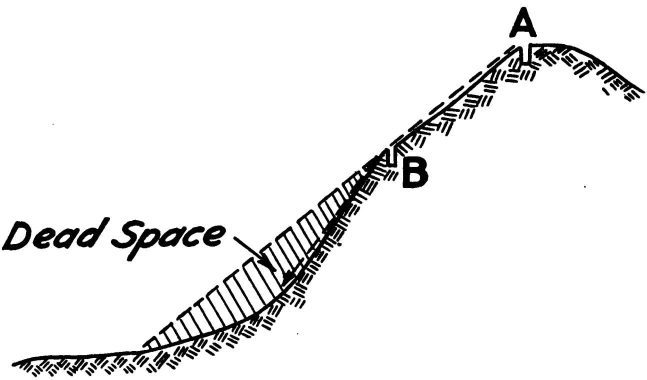


FIG. 11. TRENCHES AT MILITARY AND TOPOGRAPHICAL CREST

But even the position at the military crest may not be the best. It is advantageous because of its *command* or elevation, and the greater visibility of the field of fire thus secured; because the enemy will have to climb to reach it; and because it usually offers better communications to the rear. But it may be exposed to artillery fire up to the last minute of an attack, without danger to the enemy's infantry; shots fired from this position have a very short danger-space and small beaten zone; and if the military crest is near the top, a large percentage of *overs* may graze the crest and reverse slope, with danger to the supports and reserves in waiting there. A trench at the foot of the hill, B, Fig. 12, affords a grazing fire to the front with a long danger space, so that attacking lines of infantry cannot follow one another closely; the enemy's artillery cannot support the attack to its last stages without danger

to his own men; and complete concealment is usually easy to effect, so that the position is disclosed only when fire is opened by the defenders. A line of dummy

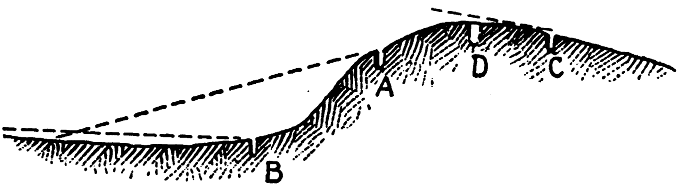


FIG. 12. TRENCHES AT FOOT OF SLOPE, MILITARY CREST AND IN REAR OF CREST

trenches, D, at the military or topographical crest will tend to draw the enemy's artillery fire away from the true position. The one disadvantage of this location is the communications to the rear, which may have to be effected by the digging of zig-zag trenches, traversed so as to be safe from enfilade fire. These, in turn, are difficult of concealment.

Some authorities advocate a double or multiple line of fire, as at A, B, and other points on the slope towards the enemy. This permits an increased volume of fire per unit width of the position, but the trenches must not be relied upon as successive lines of defense. If the first line is carried, its retreating occupants will mask the fire of the rear trenches.

The plan of placing trenches in rear of the crest, C, Fig. 12, is proposed as affording a complete concealment from observers who could direct an effective artillery fire upon the position. This plan, it is argued, allows too much dead space in the immediate front, so that the enemy may advance in perfect security to close range at the crest of the hill. Its advocates, however, claim that fire action at the mid-ranges, 300-600 yards, is impracticable during an infantry attack

properly supported by artillery, however clear the field of fire, and that in this position, the defenders do not suffer from the preliminary bombardment, and still have about 100 yards in which to stop the enemy, besides the advantage of a heavy fire at close range, delivered unexpectedly. Experience in the present war appears to justify this contention.

TRACE OF FIELD WORKS.

The ground plan of a work must be laid out to fit the terrain. Its location must not interfere with the fire from other trenches, nor must its fire be masked by their location. The line follows roughly the contour, stepping back in *echelon* at bends, as a low point in the line, like a salient angle, particularly invites attack.

In the general line to be occupied, there will be certain points more suited to strong defensive works than others. These become the skeleton, which is completed by filling the intervals with connecting trenches. The plan is extended by the construction of *Points-d'Appiu,* or supporting points, which are designed for all round defense, and are located close behind the main line of trenches, to offer a stubborn resistance and break up any attack which may penetrate the trenches. A work of this character, with a closed trace, is known as a *redoubt* or *ring-trench.*

When high parapets were the rule in fortifications an enemy who gained the protection of the outer wall was about as safe as the man inside, so the lines were traced with projections to the front and at the corners of closed works, known respectively as *salients* and *bastions,* from which the *curtain,* or line of connecting parapet, could be swept by a flanking fire. This form still survives, changed by the increased range of small arms, in the line of strongly fortified points, connected by curtains of fire trenches.

Fig. 13 shows a portion of a company trench designed for one squad, allowing one rifle per yard of front. The splinter-proof in the rear is for the purpose

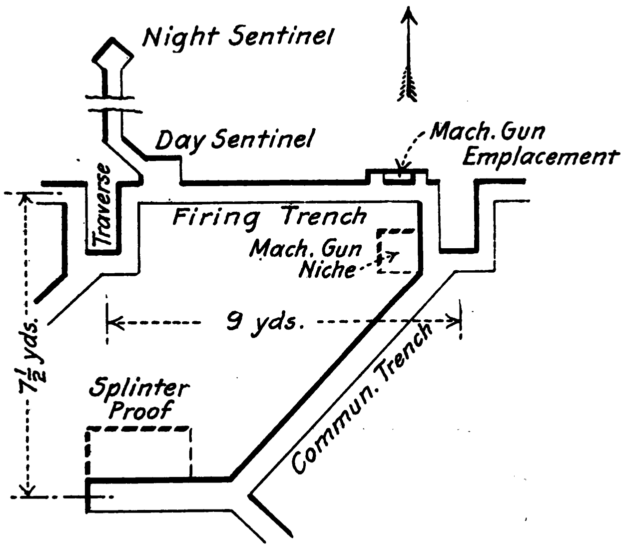


FIG. 13. SQUAD TRENCH

of sheltering the squad, excepting the sentry or lookout, during a shrapnel bombardment. In Fig. 14 is shown the complete company trench occupying a front of about 125 yards, with firing, communicating and cover trenches, splinter and bomb proofs, and dressing stations.

The flanks of a trench should not be *refused* as in Fig. 15 (a). The men in this flank trench lose all fire to the front, are exposed to enfilade, and are useless except in case of a flank attack. In (b) the trenches

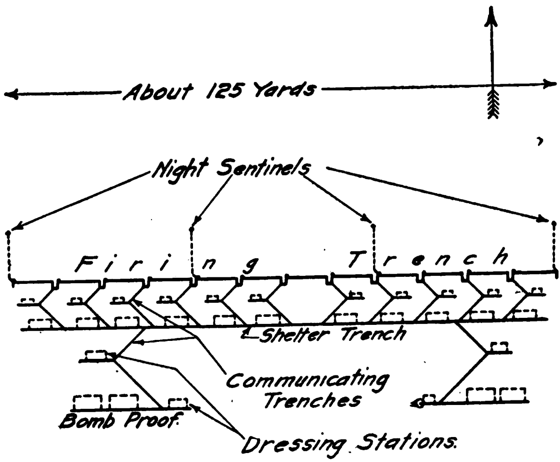


FIG. 14. COMPANY TRENCH

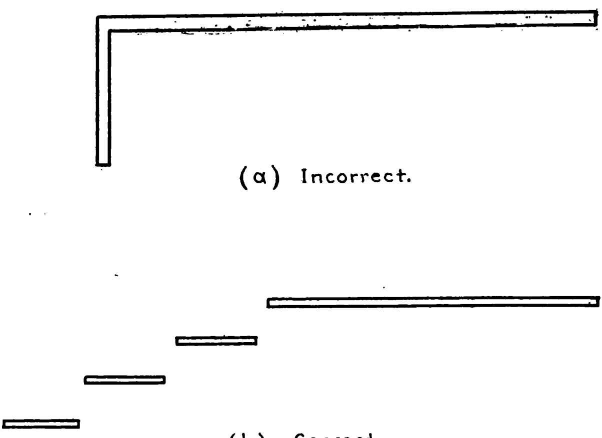
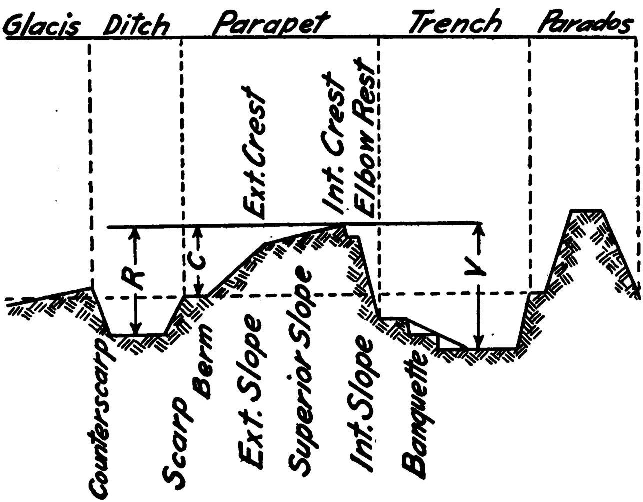


FIG. 15. FLANK OF A TRENCH

are stepped back in *echelon,* and each subdivision may fire to the front or towards the flank.

CONSTRUCTION OF FIELD WORKS.

Parapet. The typical form of parapet is shown in Fig. 16, with the parts named. This form is practically obsolete, and is shown only to give the nomenclature. The present tendency is to dispense with the ditch, lower or surpress entirely the parapet to aid



R=relief, C=command, V=vertical cover.

FIG. 16. TYPICAL PARAPET

concealment, and to deepen and decrease the width of the trench to afford increased protection from artillery fire. The *banquette,* formerly a slope up which field pieces were rolled to place them in action, is now constructed in steps, as artillery is no longer grouped with the infantry.

In permanent works, *counterscarp galleries* are sometimes built in the outer wall of the ditch and connected with the trench by tunnels under the parapet. These galleries are occupied by men who enfilade the ditch and fire into the backs of such of the enemy as penetrate this far. The position of the *exterior crest* prevents these men from firing into or being reached by the fire of the defenders in the trench. A better device is the *caponiere,* which is a low gallery built transversely across the ditch, with its roof slightly above the bottom of the latter, and the upper part of its walls pierced for rifle fire along the ditch. This structure is directly connected through the parapet with the trench.

The *parados* was formerly constructed only when reverse fire was anticipated, as in closed works, but the present war has proven it of great value in concealing embrasures and loopholes, through which otherwise light would show, in supplying a background which renders the regular shape of the parapet less conspicuous, and in protecting the occupants from the blast of high explosive shell bursting just in rear. Trenches are frequently built with a substantial parados and no parapet.

Revetments. The interior slope must nearly always be revetted. These revetments are of many varied types. For more deliberate works, *gabions,* which are large cylindrical baskets, woven without ends and earth filled, are largely used. In permanent works masonry and concrete are common. In the field, however, revetments must be improvised from the materials at hand. *Sand bags* are probably the most popular, as they will not splinter under fire and afford more flexibility in their use, but stone, logs, planks, sod, brush *fascines* and *hurdles,* and even steel sheet piling all find their use.

For *crowning* a parapet, some material which will

not splinter, as sod or sand bags, must be used. The former is cut rather thick and built up as ashlar masonry with alternate *headers* and *stretchers.* Sand bags are laid up in a similar manner, but must not be filled to a too plump form. They must be laid with a shove-joint, in order to close all crevices, and the tied ends, or *chokes,* and the seams, must be laid *in the parapet.* *Logs* and *planks* are cut to the height of the interior slope, their ends placed behind a foot log in a shallow trench, and their tops secured by a waling piece which is anchored to stakes buried in the parapet. *Poles* are laid horizontally behind vertical stakes, whose lower ends are driven in the ground and whose tops are anchored to stakes in the parapet as described above. *Fascines,* or bundles of brush, are treated similarly. *Hurdles* are woven sheets of basket work, like a gabion rolled out straight. They are secured by driving their vertical stakes into the ground and anchoring their tops. Hurdles are particularly adapted to the revetment of trenches in unstable earth, provided it will stand long enough to complete the excavation.

Traverses. A trench is protected from *enfilade,* i. e., from a flanking fire which rakes the trench from end to end, by offsets known as *traverses.* (Fig. 17a.) In order to afford a maximum development of the firing line the trench is sometimes offset to the front, but this type does not meet with much favor. The best form is the *detached traverse,* with a firing trench in front and a passage in rear, from which the communicating trench leads. Besides intercepting enfilade fire, traverses tend to localize the effects of a shell bursting in the trench. The traverse should be high enough to protect not only the trench, but the heads of men firing over the parapet. It should not, however, be higher than the parados. Fig. 17 (b) shows the effect of a bend in the trench, exposing a portion to flanking fire. This may be remedied by a longer traverse, a shorter

distance between traverses, a recess at the point exposed or a parados. The present tendency is towards a wider traverse than heretofore, owing to the use of

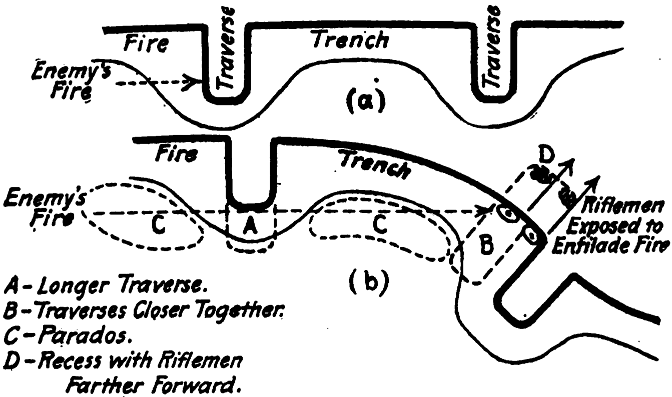


FIG. 17. PROTECTION FROM ENFILADE

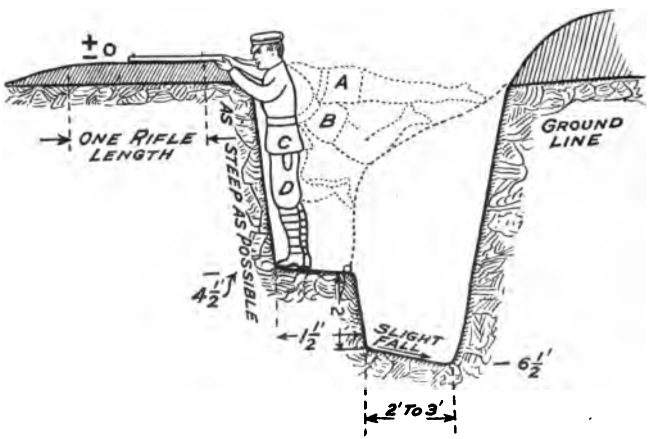
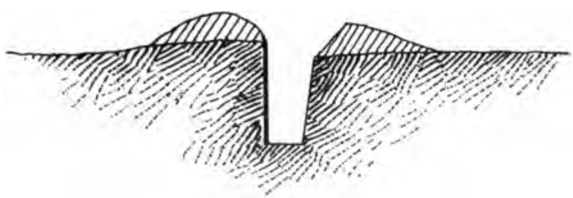


FIG. 18. DIGGING IN UNDER FIRE

high explosive shell and machine guns. The latter can cut down an ordinary traverse in a few minutes, especially if not revetted. The space under a traverse, which cannot be reached by the enemy's fire, is sometimes hollowed out and used for a magazine or store house.

Firing Trenches. In the operation of *digging in* under fire, the soldier first excavates a shallow prone trench, deepening it successively to a kneeling and a standing trench, the final step being the construction of a passageway in rear, through which a man may pass without disturbing the troops firing and without exposing his head over the parapet. (Fig. 18.) A prone or kneeling trench should not be contemplated for a moment except as steps towards a standing trench, as they are utterly useless against shrapnel.

In Fig. 19 (a) a common error is illustrated. The parapet is *not* bullet-proof, and the rifleman is exposed



(a) Incorrect.

(b) Corrected.

FIG. 19. BULLET-PROOF PARAPET

to a plunging fire, as from shrapnel or infantry at long range, from his belt buckle up. The interior slope must be revetted, and straightened up so as to increase the top thickness of the parapet and to afford cover to the rifleman to the height of his shoulders. (Fig. 19-b.)

Fig. 20 shows a plain standing trench of low parapet.

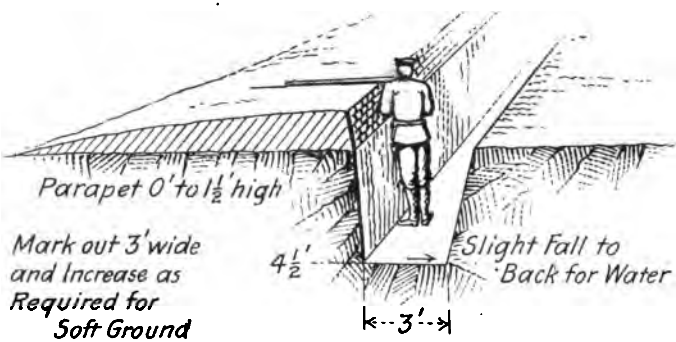


FIG. 20. STANDING TRENCH

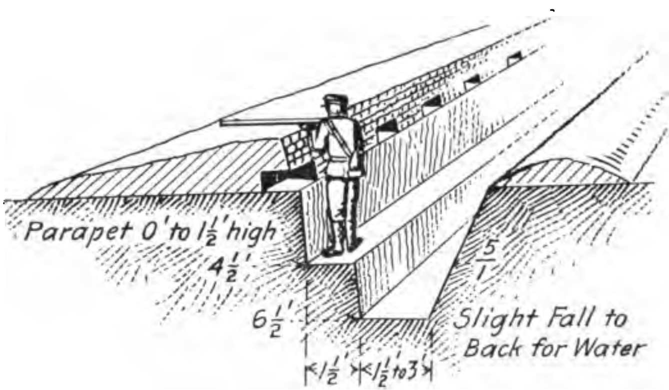


FIG. 21. STANDING TRENCH WITH PASSAGE

Fig. 21 shows the same with the addition of a passage. This latter may be excavated under fire, with the occupants of the firing step in action. The recesses in the parapet are for spare ammunition.

In Fig. 22 the parapet is entirely surpressed and the earth wasted. The firing step is replaced by a platform, allowing space underneath for resting or storage.

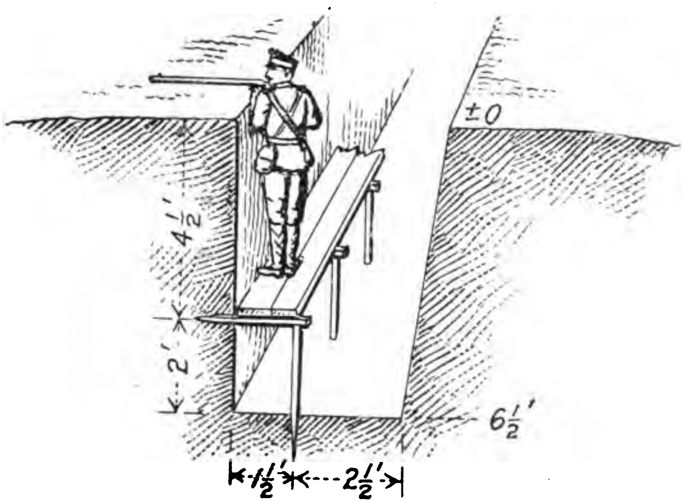


FIG. 22. FIRING TRENCH WITHOUT PARAPET

Fig. 23 is a development from a series of individual rifle pits, a connecting trench having been dug along their rear. In addition to the traverses formed by the recesses, which protect the men firing from enfilade, the passage trench itself should be traversed, to protect those using it.

Head Cover. Against a heavy fire the types of trenches described would not afford sufficient protec-

tion, and some form of head cover must be adopted. This may be formed by *crenellating* the parapet, forming notches or *embrasures* through which to fire, or by the construction of *loopholes,* which are embrasures

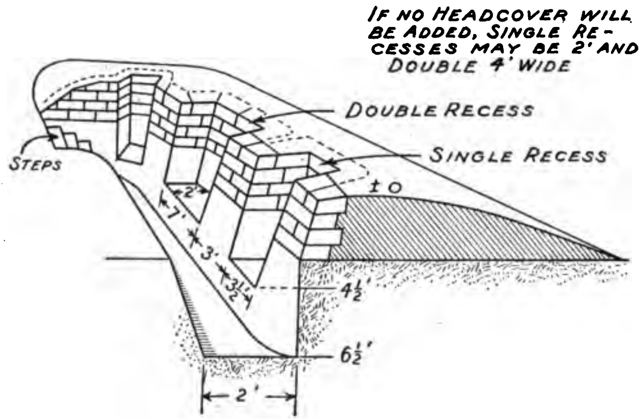


FIG. 23. RECESSED FIRING TRENCH

roofed over. A crenellated parapet does not afford as good protection as loopholes, and is usually very conspicuous, unless viewed against a high parados as a background.

Fig. 24 illustrates types of loopholes. In A a wide opening is presented to the enemy, but the rifleman has a large angle of fire with small movement on his part. The cheeks of the loophole must be stepped as shown to prevent bullets glancing in through the *throat.* In B a small opening is exposed to the enemy's view, but the rifleman must change his position considerably to alter his line of fire to any appreciable extent. Fewer men per given length of trench could be used with such loopholes than with those of the A type. In C is

shown a compromise of the two types. A steel plate, cut out as shown, is usually placed in the throat of loopholes of the C type. Loopholes should be screened if light may be seen through them, as otherwise the

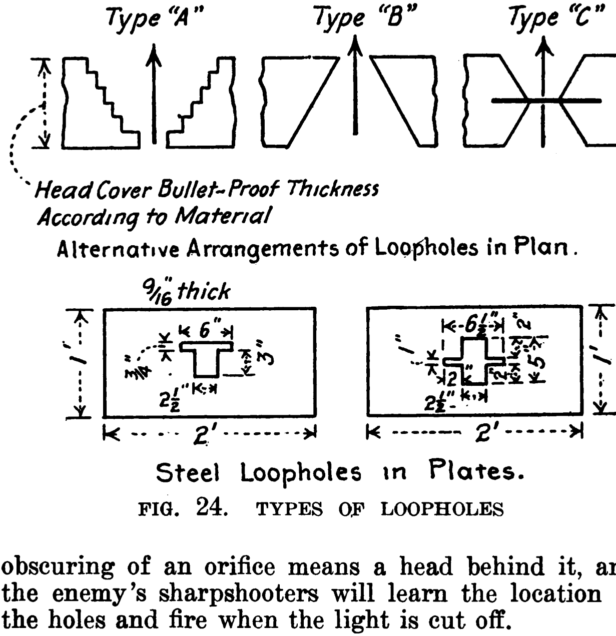


FIG. 24. TYPES OF LOOPHOLES

obscuring of an orifice means a head behind it, and the enemy's sharpshooters will learn the location of the holes and fire when the light is cut off.

Fig. 25 shows a common error of the individual soldier in constructing a loophole and how it may be avoided. It is usually necessary to examine all loopholes built by enlisted men and see that an unobstructed field of fire in the proper direction is afforded.

Overhead Cover. Under shrapnel bombardment head cover alone is insufficient, and overhead cover must be provided. The simplest form is that prepared by the

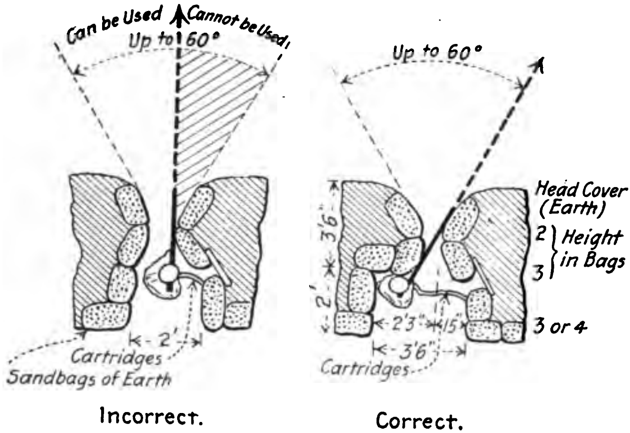


FIG. 25. LOOPHOLE CORRECTED FOR WIDE ANGLE OF FIRE

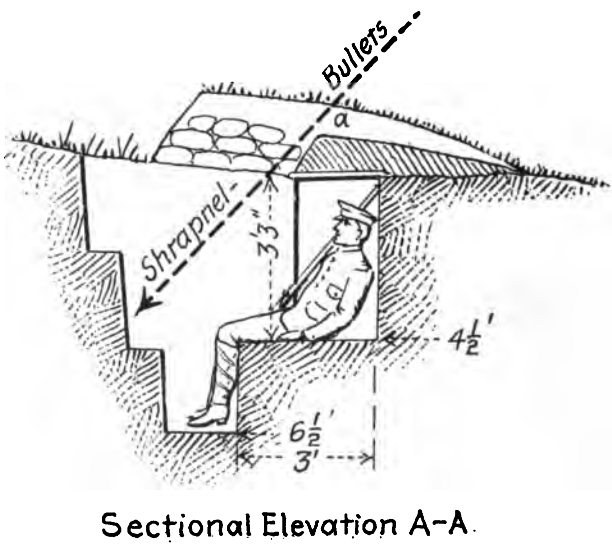


FIG. 26. INDIVIDUAL OVERHEAD COVER

individual soldier, Fig. 26. Boards are laid on the ground and covered by the parapet as the excavation of a plain standing trench proceeds. The niche is finally scooped out under the boards. He occupies this recess during an artillery bombardment and uses the standing trench for firing. Fig. 27 shows a somewhat

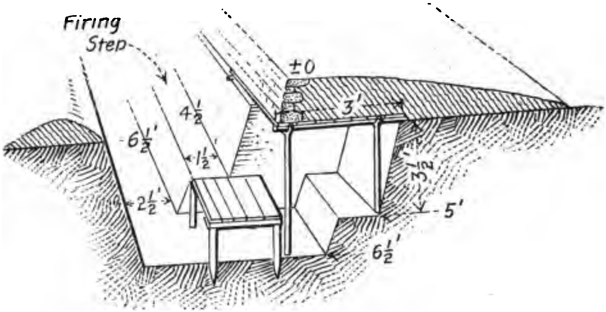


FIG. 27. PARAPET SHELTER

more elaborate form, designated a *parapet shelter.* The wooden platform provides a continuous firing step. Such overhead cover contains from one to two feet of earth and is known as a *splinter-proof.* A *bomb-proof* is built to resist high explosive shell, and is roofed with heavy timbers covered with six to twenty feet of earth. Broken stone covered with earth is also used for overhead cover.

The highest type of firing trench is one completely roofed over by splinter-proof construction, loopholed to the front, and accessible by stairs or communicating trenches to the rear. (Fig. 28.)

Firing trenches which are liable to be rushed, or from which a charge is to be made, must be constructed without head or overhead cover. Otherwise the troops will find it impossible to leave the trench in a body to

make a rush, and they will be caught like rats in a trap by a successful charge of the enemy. A man in even an open trench is at a considerable disadvantage

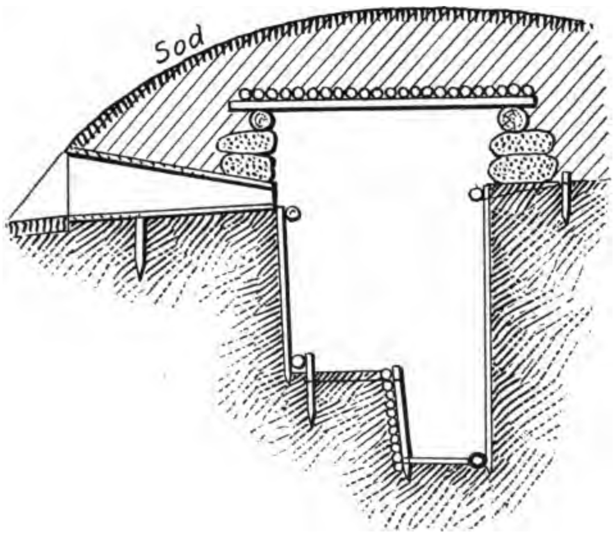


FIG. 28. FIRING TRENCH WITH OVERHEAD COVER

against an enemy with a bayonet who reaches the crest above him, but if inclosed by overhead cover, the entire garrison of a trench may be annihilated by hand grenades thrown through the loop holes. The Japanese battle regulations specify that the defender shall not await the final rush to the edge of the trench, but shall leave his trench and counter-charge with the bayonet as soon as the obstacles are passed. Egress from firing trenches to the front may be facilitated by digging a couple of steps in the front face and setting a stake in the parapet, to be grasped by the hand in climbing

out. Unless some such device is constructed, much valuable time may be lost in commencing a charge.

Cover trenches are provided for troops in reserve, and may be entirely inclosed, with no facilities for firing, and connected by communicating trenches with the firing line. (Fig. 29.) In a cover trench occupied

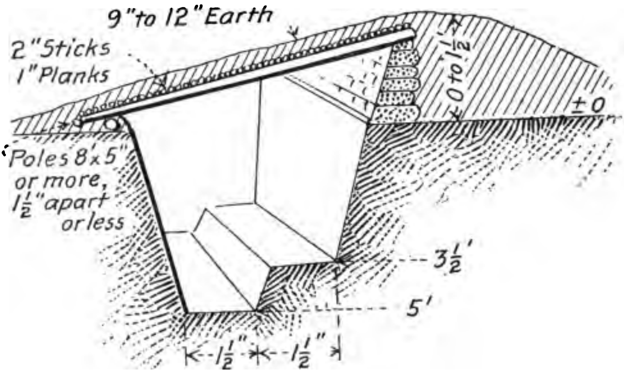


FIG. 29. COVER TRENCH

by troops on duty only, as in a combined fire and cover trench, six square feet of floor area must be allowed for each man. For more continuous occupancy, twelve square feet, and for habitation of long duration, eighteen to twenty square feet, are required. The thickness of overhead cover required depends upon the nature of the fire it will have to resist. It may vary therefore from a splinter-proof roof one foot thick to a bomb-proof of any desired depth. Points whose protection is of the greatest importance, as telephone central stations and posts of important commanders, may be placed from thirty to forty feet underground.

Communicating trenches are constructed in zig-zags

to prevent enfilade, and lead from the cover to the fire trenches. They are built very narrow and deep, with passing points hollowed out of the walls at frequent intervals. The excavated earth is piled up on both sides, to reduce the amount of digging, and at the junctions of the diagonals are located short stretches of trench (returns), in which are located the first-aid dressing stations and the sanitary arrangements. All earth must be disguised to resemble the surroundings.

Machine gun emplacements are located at frequent intervals along the line, the intention being to move the guns from one emplacement to another as their effectiveness can be thus increased, and as the enemy's fire becomes too severe for them in other locations. Fig. 30 shows a typical machine gun emplacement. When this type is used, however, it has been

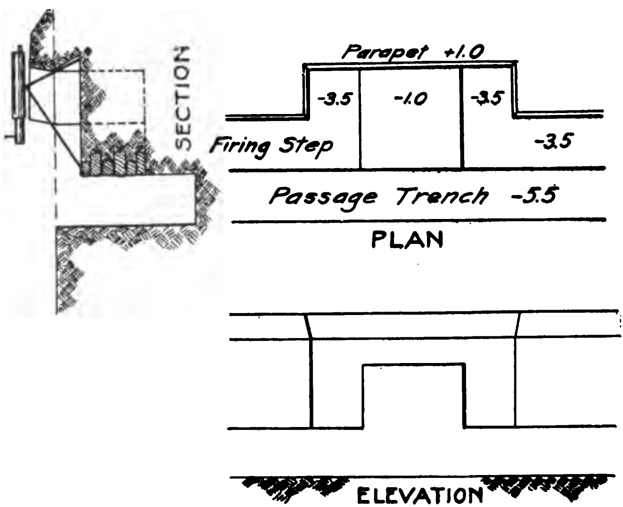


FIG. 30. PLAN OF MACHINE GUN EMPLACEMENT

found that the enemy will concentrate his fire upon the machine guns and put them out of commission at the first. The method now recommended is to place the

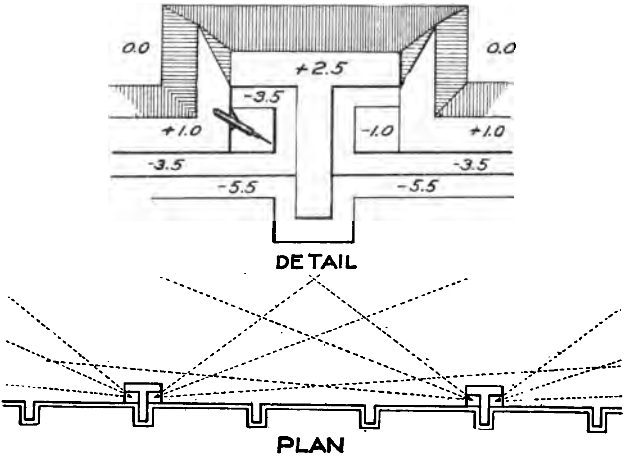


FIG. 31. MACHINE GUN EMPLACEMENT

machine guns behind a strong parapet, with no facilities for frontal fire. From behind the flanks of this protection, which is only slightly higher than the firing parapet, they cover the space between emplacements by a cross-fire. (Fig. 31).

Gun cover is secured by two methods, *epaulments* and *pits*. In the former, a low parapet is constructed in front, to fill the space between the ground and the gun shield, higher embankments on the sides, and trenches in the rear for the gun crew. A trench is usually provided for the ammunition, of which a large stock must be on hand if a heavy fire is to be maintained. If the fire is to be delivered at a high angle, the gun may be sunk into the ground, and a long slop-

ing trench dug in prolongation of the barrel. The excavated earth is piled on the sides, as the shield usually suffices for frontal cover.

CONCEALMENT OF FIELD WORKS.

Concealment is now considered of prime importance in the location and construction of field fortifications. In fact, troops that are well hidden from the enemy are probably safer than those which are sheltered in strong works but still under his observation.

Disguising.

The sky line must be avoided, as it is practically impossible to treat the outlines of the parapet so as to disguise its real identity. Also, regular outlines and particularly the abrupt ending of a parapet, tend to betray the position of a work. A safe rule to be followed is that the natural appearance of the terrain is to be changed as little as possible. Concealment is therefore facilitated by surpressing the parapet, making it conform to the general shape of the ground, and narrowing the trench on a forward slope, so that its rear edge is not visible over the parapet. Sod over the space which will be occupied by the trench and parapet should be removed and carefully replaced over the complete parapet, so as to hide the fresh earth. This is best accomplished by cutting the sod in strips and rolling it towards the enemy, afterwards rolling it back over the parapet. In this connection it should be remarked that the mere covering of the parapet with material of the same color as the surroundings does not necessarily conceal it, as its apparent color to the enemy may appear quite different when viewed on the steep slopes of the parapet and on the adjacent level ground, owing to the varying light reflections.

The transplanting of small trees, bushes, etc., which

must be placed in front of rather than on the parapet, will aid concealment, but the scattering of leaves, branches, etc., over the earth, or the sticking of limbs of trees into it, are worse than useless, as the fresh vegetation soon withers and renders the position more conspicuous than before. Dead leaves, twigs, etc., are excellent, provided the surrounding earth is covered with the same material. It goes without saying that neighboring patches of ground should not be denuded of sod and rendered highly conspicuous in order to provide covering for the parapet.

Dummy Trenches are a very useful adjunct to concealment, as directing the attention of the enemy away from the occupied works. They are most effective when they present the appearance of real trenches ineffectually concealed rather than excavations made without any attempt at hiding them. In short, the enemy's attention must not be too expressly invited to them. The turning over of a two-foot strip of sod, with perhaps a foot of excavation at the rear edge, will usually be sufficient. Dummy trenches must not be placed where fire directed at them will endanger the true position.

Dummy artillery positions are sometimes prepared with considerable care, and are very effective when the details are well carried out. According to a recent British publication, an excellent Quaker gun may be made from a section of a telegraph pole and the fore truck of a farm wagon, with boards for gun shields. If at intervals a couple of ounces of gunpowder are placed on a tin shelf at the muzzle, and fired electrically, especially at the same time a real gun is fired elsewhere, the enemy may be tempted to waste many rounds of perfectly good live shell.

Concealment from Aerial Observers. It has been found from the present war that nearly all trenches are easily visible to the enemy's air scouts, but if care has been taken to remove from the adjacent ground all

prominent marks by which the observer can locate the trenches to the gunners, the latter will have considerable difficulty in getting on the target from the observer's description. All prominent trees or clumps of vegetation, buildings, light-colored rocks, wind-mills, etc., that might thus serve as reference points should be avoided in locating the trenches, or cleared away from the vicinity.

While the trenches are usually seen without difficulty, it is hard to determine, from the height at which the reconnaissance must be made, whether or not they are occupied. The straw which is sometimes placed in the bottom of trenches to protect the feet of the men from wet ground adds greatly to their visibility and aids in ascertaining their occupancy. The paths which may be worn to a trench or more particularly to a gun position often result in the betrayal of a work which would otherwise escape notice. Also, the absence of such paths to an otherwise obvious gun position may proclaim the latter as a dummy.

CHAPTER IX.

OBSTACLES.

Fire action alone will not stop a determined enemy. It has been found that troops will not remain to meet a charge if it advances too close for comfort. Therefore some obstacle must be presented to an advance beyond a certain point. Natural obstacles may be taken advantage of where encountered, but these are not plentiful, and are seldom situated where they can be effectively used.

Obstacles must not be constructed as part of the defensive works of a position without the authority of the officer commanding the section of line, as they may interfere seriously with contemplated movements of the defending troops, when a change is to be made to the offensive. Furthermore, obstacles should not be made continuous along the entire front, as they will prevent counter-attacks and the resumption of the offensive by our own troops. The gaps are swept by concentrated fire from machine guns and specially designated units. When openings are left in this manner, the way of approach of the enemy is in a measure predetermined, as attacking troops will always crowd towards the gaps. Care must be taken that works otherwise well concealed are not betrayed by the obstacles erected to protect them.

Barrier Obstacles. To be effective an obstacle must be concealed from the enemy, it must not afford any cover to an attacking force nor obstruct the fire of the defense, and it must be difficult of destruction. Obstacles are best located at a short distance in front of the parapet. This distance varies considerably as

recommended in the service manuals, 50 to 100 yards being usual, but with the short field of fire allowed by approved practice in the present war, this figure may be materially reduced. Some photographs of actual works shows the obstacles placed against the parapet. It is said, however, that such close proximity is objectionable, as it permits the enemy's grenade throwers to approach at night and bombard the trench.

Some types of obstacles are shown in Fig. 32, which is reproduced from the Engineer Field Manual, U. S. Army. The *abatis* consists of large branches of trees, which are trimmed of all foliage and small limbs, their ends sharpened, and then laid in several rows, the pointed ends towards the enemy. The butts are firmly staked down and barbed wire is interlaced among the branches. An abatis is easily destroyed by artillery fire unless concealed in a natural depression or a ditch. It may also be protected by raising an embankment in front of it, with a long sloping glacis towards the enemy.

A *slashing* is a quick substitute for an abatis, by cutting trees nearly through and felling them towards the enemy. This, however, is liable to afford too much cover to the attack unless swept by cross-fire.

A *palisade* is a strong fence. It must not be made of poles large enough to give protection to a man, and it must be securely set in the ground. This is best accomplished by burying the butts of the poles in a trench, with stone wedges between the butts and log waling pieces on one or both sides. A waling piece above ground assists materially in scaling the obstacle, but strands of barbed wire at the top add to its effectiveness.

A *fraise* is a horizontal palisade or wire fence built out from the scarp or counterscarp of a ditch.

Roads may be closed, especially against cavalry, by *chevaux de frise,* which are obstacles built in "saw-

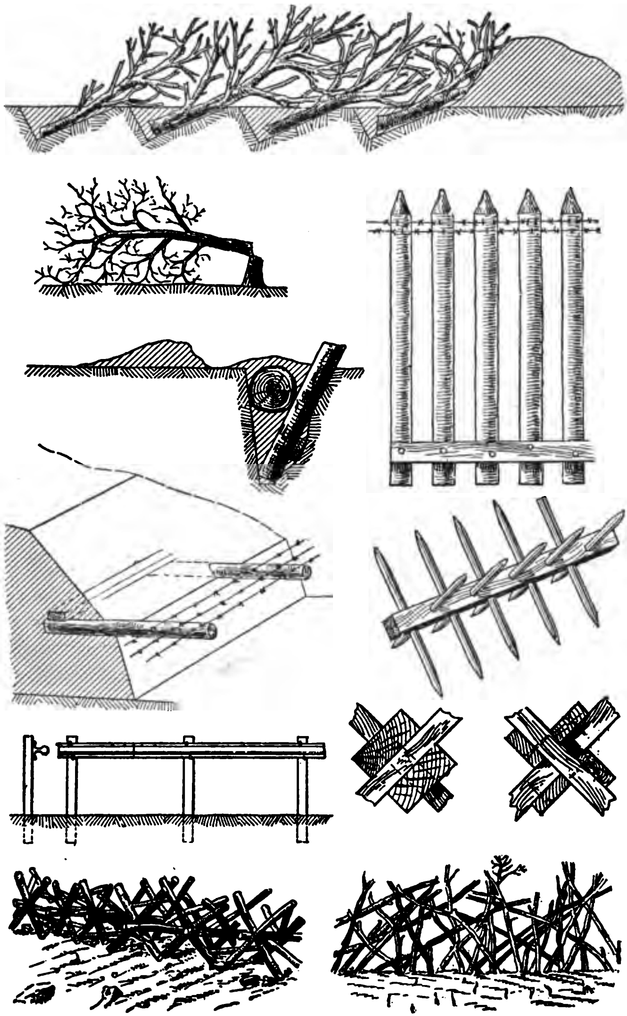


FIG. 32. OBSTACLES

buck'' form. They are constructed in sections and chained together. The figure shows how they may be built up of dimension lumber. Cavalry may also be stopped by setting railway ties in the ground and spiking a rail along their tops four or five feet from the ground.

If the topography permits, a very good obstacle may be formed by flooding the ground immediately in front of the works. This may be impracticable, however, on account of the labor involved.

At the bottom of Fig. 32 are shown two types of obstacles used during the Russo-Japanese War. The Russian type, consisting of heavy timber trestles, was prepared behind the lines and carried out in place. The Japanese obstacle was constructed by sticking light poles into the ground and wiring them together where they crossed, or by treating in the same manner the trunks of young trees growing in place.

The *wire entanglement* has come to be accepted as the standard form of obstacle, and possesses many advantages over most other types. It cannot be easily destroyed by artillery, it is extremely difficult of passage, affords no cover to the assault, is not conspicuous at any distance, and is fairly rapid of construction. Fig. 33 shows a common type, two panels wide. Note the great difference in the size of the openings left by staggering the center row of posts as against placing them rectangularly. The wires must be strung loosely, as they are thus less easily cut by blows from a bayonet or machete. No horizontal wires are placed on top, so that any attempt at crossing the entanglements on planks or ladders will be defeated by their tipping over.

In the European War, it has been found that the noise of driving posts for entanglements at night will draw a heavy fire upon the working party, so it has been the practice to construct wooden forms or trestles

inside the works, string them with barbed wire, and place them in position at night. They are chained or lashed together, and are sometimes anchored back to the trench, to prevent the enemy's hauling them away by means of grapnels.

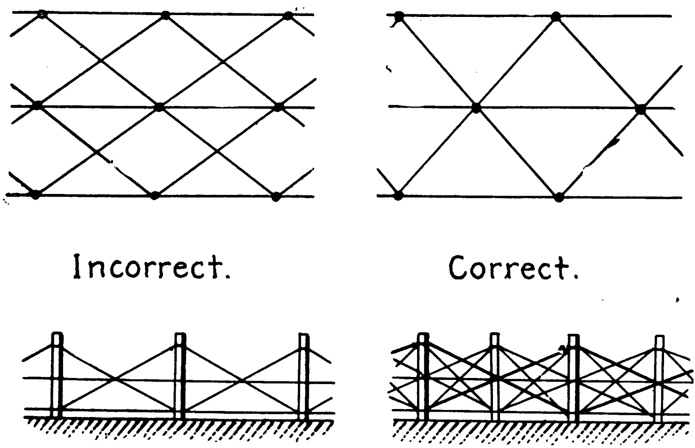


FIG. 33. WIRE ENTANGLEMENTS

Destroying Obstacles. Wire entanglements are destroyed by cutting the wires with clippers or bayonets, or by throwing a heavy grapnel over them by means of a trench mortar and hauling it back. A pole containing a chain of dynamite cartridges may be laid or thrown across the entanglement and the charges exploded. This will cut all the wires in contact with the pole, but little progress can be made in this way towards the destruction of the entire obstacle, and the opening of one passage will cause an attacking force to concentrate and offer an excellent target for machine guns.

An abatis or slashing is attacked by cutting the interlaced wires with pliers, opening up a way through the obstacle, and attacking it in the rear with axes. The branches may be easily cut from the rear, pulled out of the abatis and cast into piles. A long string of explosives on a pole, as described above, will be useful in effecting the first breach.

Palisades, fraises, and chevaux de frise are attacked by axes. They are more easily destroyed under fire than the other types described. At night, parties may pile brush around them and set it afire. Floods may be reduced by cutting the dam which backs up the water, if it can be reached, or by opening an outlet for the water to lower ground. When very low lands are flooded by cutting ocean dikes, as in Belgium, there is little that can be done except to attack with boats and rafts, by night.

Flares and Alarm Signals. As most attempts at cutting obstacles will be made at night, some form of alarm must be provided to warn the defenders. The best of these burst into fire and not only give a signal but illuminate the obstacles sufficiently to guide the fire of the defense. They are usually operated by *trip* or *cut* wires. The former operate by the enemy's pulling or tripping over them, the latter by being cut and releasing a weight, which, in falling, actuates the alarm. Some signals are arranged to operate either upon a pull or by the slacking of the alarm wire. The weight may be attached to a cord which will pull the trigger of a rifle, or may fall upon a cartridge. A shot, however, is not sufficient where shots are being constantly fired, and the same apparatus may be made to ignite a flare by inserting an instantaneous fuse in the cartridge and leading it to a heap of gunpowder in a prepared bonfire. The latter, if intended to remain for some time, must be roofed over with canvas or boards. Where entanglements are close, pieces of tin and iron

may be hung upon the wires, to rattle when disturbed. When the alarm has once been given, a flare consisting of a rag ball, wound upon a wood block, saturated with oil and rolled in gunpowder, may be fired from the trench by a gas pipe cannon, using a small propelling charge of powder. This will burn for a short time and disclose the nature of an attack. For more complete illumination, bonfires may be ignited from the trenches by electricity or an instantaneous fuse. They should of course be screened to prevent lighting up the trenches.

No form of automatic alarm must be allowed to take the place of alertness on the part of the defense.

Land mines are temporarily effective as an obstacle. They are planted in several lines and usually fired electrically by successive rows. A land mine proper is exploded as the enemy crosses it, a *fougasse* is arranged to blow stones in the face of a charging enemy. (Fig. 34). Mines must not be so heavily charged that

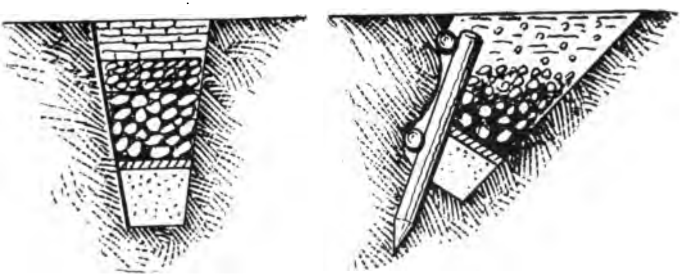


FIG. 34. LAND MINE AND FOUGASSE

their craters will offer cover to advancing troops, but *unless* the charge is heavy, their actual execution will be small. The effect of land mines, therefore, is mainly moral, it being difficult to send troops across a field known or supposed to be mined, or in which mines have been exploded. To determined troops, however,

they cannot be relied upon to furnish a permanent barrier.

Fig. 35 shows the explosion of a row of land mines laid by the engineers at the "Battle of Martins Mountain," during the Fishkill Plains maneuvers of the First Brigade, N. G. N. Y., season of 1915. The trenches in the foreground were occupied by the 71st N. Y. Infantry, part of the defending troops.

FIG. 35. LAND MINES

TABLE OF MEN, TIME, AND TOOLS *

REQUIRED FOR THE EXECUTION OF CERTAIN FIELD-WORKS.

Note.—Except where otherwise stated, the material and tools are assumed to be on the site of the work. All tracing and marking is to be done before the distribution of the working parties at the sites. Not more than five minutes should be consumed in distributing the men or in changing reliefs, if the men have been told off into suitable groups or parties under leaders previously instructed in the nature of the particular works in hand. One leader or foreman can conveniently supervise up to twenty unskilled men on earth-work.

*From the British Manual of Field Engineering.

No.	Nature of Work.	Minutes of One Man.	Per Unit of Task.	Suitable Unit Party.	Tools per Party.
	ENTRENCHING.				
1	Excavation only.	3	1 cub. ft.	1	1 shovel and 1 pick
2	Ditto, in small recesses, shelters, etc......	9	1 cub. ft.	1	Ditto
3	Shovelling loose earth	1	1 cub. ft.	1	1 shovel
4	Removing fifty yards (average) deposit, and return ...	2 1	1 cub. ft. 1 cub. ft.	1 2	1 barrow 1 stretcher
5	Filling sand-bags	3	1 sand-bag	3	2 shovels
6	Head cover, sand-bags or sods..	60	1 loop-hole	1	1 shovel
7	Overhead cover, added to head cover in a recess	60	1 rifle	1	1 shovel, 1 hand-axe
	REVETMENTS.				
8	Brushwood, rough or planks	1½	1 sq. ft. (Revetted)	2	1 bill hook, 1 mallet
9	Sand-bags or sack	3	1 sq. ft. revetted	2	....
10	Sods, building with		1 sq. ft. revetted	2	1 shovel or spade
11	Sods, provision of (for above)		1 sq. ft. revetted	3	3 sharp spades
	CUTTING AND FELLING.				
12	Trees, felling, up to 12 in. diam.	1	1 in. of diam.	1	1 felling axe or saw
13	Woods, clearing of brushwood and small trees	2½	1 sq. yd.	20	10 bill-hooks 4 felling axes 4 hand axes, 2 saws 1 grindstone 2 whet-stones

No.	Nature of Work.	Minutes of One Man.	Per Unit of Task.	Suitable Unit Party.	Tools per Party.
	CUTTING AND FELLING.				
14	Hedges (felling stems)	10	1 yd. run	2	1 bill hook or hand-axe. 1 saw, 3 fathoms rope
15	Brick wall, notches in up to 18 in.	10	1 notch.	1	1 pick crow-bar, or mason's chisel and hammer
	OBSTACLES.				
17	Abatis, and wired (one strong row)	120	1 yd. run	20	As for item 13; also 2 mauls, 3 pr. pliers, 1 pickaxe, 1 shovel
18	Wire Entanglement	60	1 sq. yd.	3	1 bill-hook, 1 hand-saw, 1 maul, 1 pr. pliers, 1 pr. wire-cutters. 3 rag pads for gripping and straining wire. *In hard ground add*: 1 steel jumper 1 sledge-hammer

CHAPTER X.

SIEGE WORKS.

Investment of a fortified place is accompanied by various activities which, on account of the time required, have no place in ordinary field works. Siege operations comprise defensive cover for the attackers, mines for the destruction of the defenders' works and saps to bring the attacking forces within assaulting distance.

Sapping. A *sap* is a zig-zag trench approaching the point of attack. (Fig. 36). It may be *right-handed* or *left-handed,* according to whether it gains ground to the right or left; and *single* or *double,* according to whether it is driven by one man, heaping the excavated earth on the side nearest the enemy, or by two men working side by side, and heaping the earth on both sides. The latter is the usual form near the enemy, where both sides must be protected, and in this case the sap is pushed forward as a double trench, the tongue of earth between being removed by soldiers following the sappers, similarly to the progressive order of excavation followed in tunneling.

Sapping is begun from the *first parallel,* which is a firing trench established as near as practicable to the enemy's works. A sap should not extend more than about 100 feet without a change of direction, and each branch should cover the head of the preceding branch by overrunning it several feet. When a point five or six hundred feet from the enemy is reached the *second parallel* is constructed, and from this a heavy rifle and machine gun fire is kept up to protect the sapping

operations. The *third parallel* is placed about half way between the second and the point of attack, and an assault will usually be made from this location,

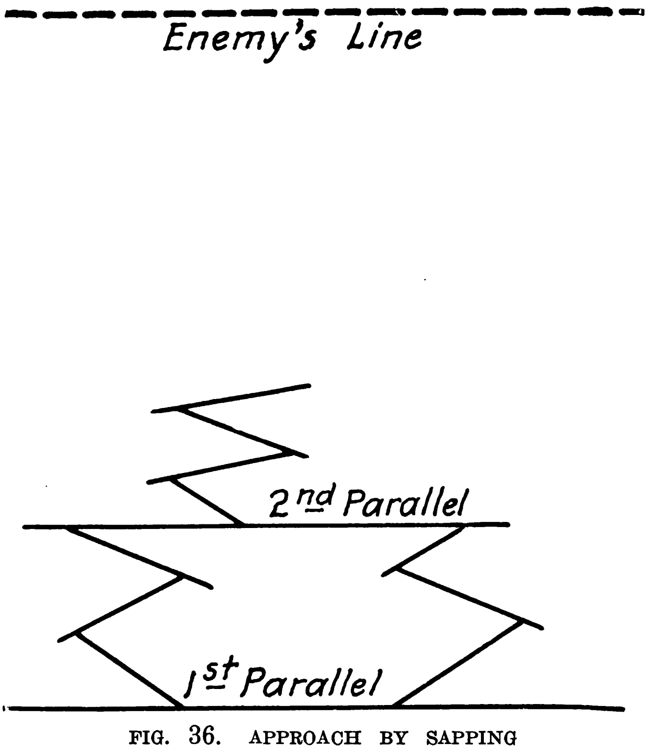


FIG. 36. APPROACH BY SAPPING

though it may sometimes be necessary to carry the work still further.

As the enemy's works are approached more closely, the inclination of the saps becomes flatter and flatter,

to avoid enfilade. Finally, protection must be obtained by rolling a pile of sand bags ahead of the sap and by the use of *overhead traverses.* These are constructed by placing boards across the sap and covering

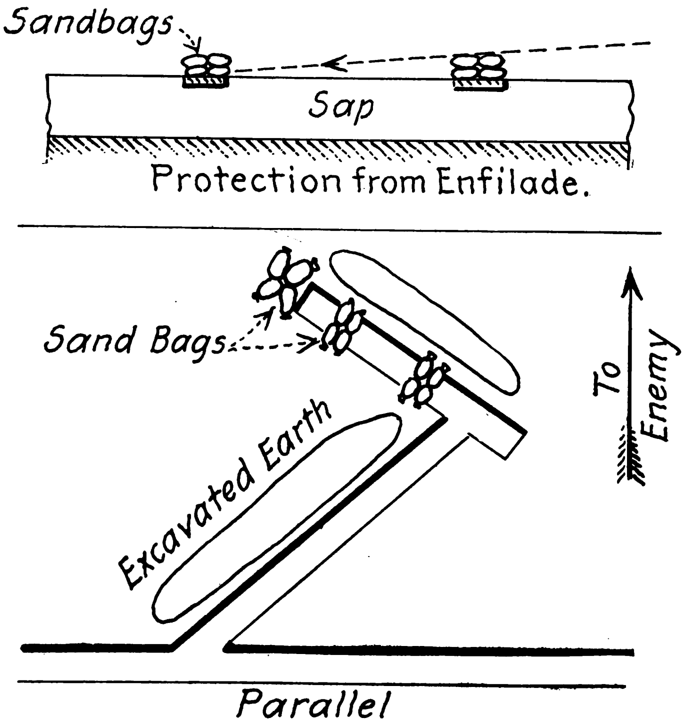


FIG. 37. A SAP

them with sand bags. They must be so spaced that a shot clearing one will be intercepted by the next. (Fig 37). This distance is made less as the work proceeds,

and finally the sap becomes a covered way. Further advance must then be made by mining operations.

Mining comprises underground approaches for the purpose of placing and firing charges of explosives under the enemy's works. A mine consists of a *shaft,* sunk vertically, and one or more *galleries,* driven hori-

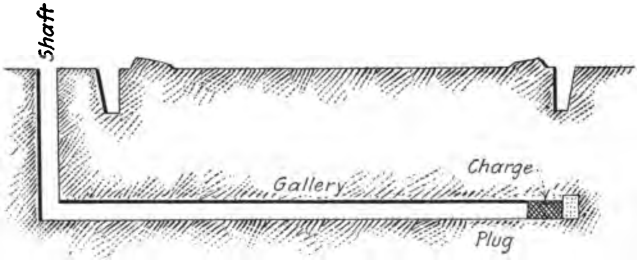


FIG. 38. MINE

zontally. (Fig. 38). If the gallery can be started from a ditch, bank or hillside, the shaft may be dispensed with, and much trouble avoided in carrying the alignment underground.

Mines must be driven in earth. Drilling and blasting operations are impracticable with the equipment ordinarily available, and the approach of the mine would be known to the enemy long before it was ready for use. Nearly all the work, therefore, must be protected against caving, and the timbering calls for all the skill of the miner and tunnel worker. Difficult soil is often encountered, and full sheeting of the shafts and galleries is the rule rather than the exception. Timbering is accomplished by the method of *frames and sheeting* if the earth is unstable, or by *cases* where it will stand long enough to allow their being placed in position. (Fig. 39).

The alignment of a mine involves quite complicated underground surveying, and must never be placed in charge of other than an experienced officer. For changes of direction *bevels* are made above ground

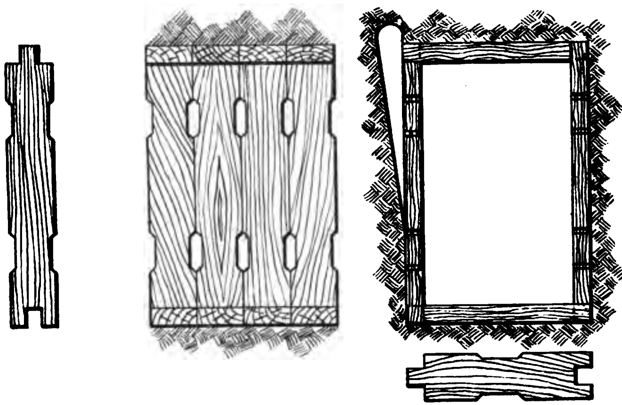


FIG. 39. MINE TIMBERING

from strips of board, and applied to the angle as laid out in the mine. In fact, the operations of mining, timbering and alignment conform so closely to civilian mining practice that it is usually sufficient to point out the purpose to be accomplished and turn the work over to officers and men experienced along this line.

When the mine is completed, the *charge* is placed, the officer directing the work being designated to perform this duty personally. The amount of explosive used must be sufficient, for while some is wasted if an overcharge is placed, it will *all* be wasted if the mine fails of its purpose from undercharging. The *plug*, usually of sand bags, is placed, and troops are massed in the last parallel for an assault. These troops rush

forward as soon as the mine is fired, occupy the crater and begin to entrench against a counter-attack. Engineers accompany the attack and assist in organizing the position for defense.

The only defense against mines is the *countermine.* (Fig. 40). The sound of working in earth can be heard for a distance of thirty to forty feet through the ground, even when care is exercised, and an alert enemy will have *listening galleries* driven out in front of his works and occupied by observers. When the approach of a hostile mine is detected, the listening gallery may be converted into a countermine by charging it and exploding it when the attacking heading comes within its *radius of rupture.*

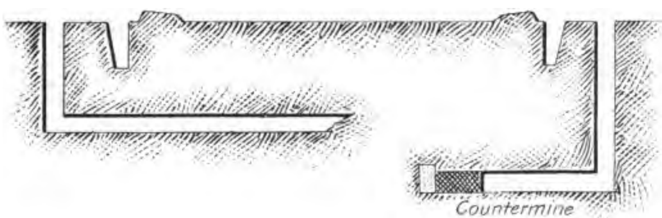


FIG. 40. COUNTERMINE

The usual aim in countermining is to blow in the *side* of the hostile mine some distance back from its heading, so as to destroy as long a section as possible of his work and for the reason that the crater of the countermine may be occupied by the attack, and should not therefore be formed near the defenders' position.

A *camouflet* is a countermine so charged as to blow in the attacking mine without disturbing the surface of the ground. Hence no crater is formed,

Rate of Workings. The following table gives an estimate of the men and tools required for shafts and galleries, with the probable rate of advance in good soil:

RATE OF WORKING.

Kind of gallery, etc.	Men.		Tools.														
	N. C. officers.	Miners.	Picks.	Miner's Picks.	Push Picks.	Shovels.	Miner's shovels.	Miner's truck.	Field levels.	Measuring rod, 6'.	Tracing line.	Mauls or sledges.	Canvas buckets.	Rope ladder.	Wheelbarrows.	Miner's bellows.	Progress, ins. per hour.
Great gallery or blind gallery....	1	*12	4	2	2	8	...	....	1	1	1	1	...	...	4	...	12
Common gallery...	1	4	...	1	1	2	1	1	1	1	1	1	...	...	...	1	12
Half gallery.......	1	†4	...	1	1	2	1	1	1	1	1	1	...	...	...	1	16
Branch gallery....	1	†4	...	1	1	2	1	1	1	1	1	1	...	...	...	1	24
Small branch......	1	8	...	1	1	...	2	§1	‡	1	1	1	...	...	...	1	30 to 36
Shaft.............	1	‖4	...	1	1	2	1	....	1	1	1	1	1	1	...	...	18 24

From Engineer Field Manual

* Four of these may be unskilled laborers.

† Number required at commencement of gallery. Beyond 4 ft. add one man, and one man additional for every 20 ft. of gallery.

‡ One mason's level.

§ Instead of a truck a canvas bag may be used. A large hoe or drag may be used to draw back the earth from the face of the gallery.

‖ These numbers are for small shafts of about 2 ft. by 4 ft. Large shafts require a larger force. They advance at about the same rate as galleries of equal cross-section.

CHAPTER XI.

DEMOLITIONS.

An important part of the engineer's work in the field is the demolition of obstacles or hindrances to his own advance, and of things which may prove of material assistance to the enemy. His two principal agents are fire and explosives.

HIGH EXPLOSIVES.

Regarding the latter, there appeared recently in the "Columbia Alumni News," New York. Vol. 7, No. 20, Feb. 18, 1916, page 581, an article on High Explosives by M. C. Whitaker, Professor of Engineering Chemistry. This article had been delivered as an address to the Columbia Alumni, and the material is so applicable to the subject in hand, that, with the permission of Prof. Whitaker, it is here presented entire:

"The popular idea of an explosive is gunpowder. This is a mixture of 75 per cent. saltpeter, 10 per cent. sulphur and 15 per cent. charcoal. These substances are carefully ground together and pressed into a cake. After being carefully dried the cakes are broken into lumps and sized in order to produce the different grades of powder required. The size of the particles has a direct bearing on the rate of combustion, and by the proper selection a suitable explosive is thus found to meet the requirements of the different sized guns, ranging from small rifles to heavy mortars.

Within the span of our lives, however, the manufacture of explosives has undergone a great change. The requirements for explosive powder and accuracy have become more exacting as the range of the guns and the

accuracy of gun fire has increased. We have been tremendously impressed at the reports of the results of the heavy artillery in the European war, but it is doubtful if the layman has given much study or thought to the means by which these results have been accomplished. For our purposes we may arrange explosives into (1) that class of materials which give their explosive force through rapid combustion, e. g., gunpowders, smokeless powders, etc.; (2) the class which derives its explosive force from detonation, e. g., nitroglycerine, guncotton, picric acid and trinitrotoluol; and (3) detonators, or those substances which explode with extreme violence on the application of heat or a shock, such as fulminates.

Combustibles and Detonants.

The combustible explosives are sometimes classed as low explosives and the detonatable materials as high explosives, and, again, the combustible explosives are frequently classed as propellants, while the detonatable substances are classed as disruptive explosives.

In the old style explosives, such as gunpowder, the explosive constituents were mixed together as intimately as possible, while in the new type of powders the constituents required to produce an explosive effect are contained in the molecules of the chemical compound. This change in the make-up of an explosive substance has the effect of increasing the speed with which the explosive action takes place, and fixing with accuracy and definiteness the composition of every particle of the explosive material. Accurate control of the composition of the explosive, uniformity throughout its entire body and the definiteness of its composition are factors which control the dependability, accuracy, safety and all other elements in the modern practice of gun fire.

It is obvious that the pressure exerted by the charge

of exploding powder on the projectile must be uniform for every shot, otherwise it would be impossible to rely upon the propellant to obtain duplicate results. The force of a propellant depends upon its decomposition into gases at greatly elevated temperatures, and the pressure which is exerts upon the breech of the gun and the projectile is dependent both upon the amount of gas produced and the temperature generated by the explosion. It is clear from this that any slight variation in the composition of the powders would result in wide variations of both temperature and pressure. It is interesting to note what these pressures and temperatures actually are:

	Lbs. per sq. in.	Temp.
Gunpowder	30,815	2910°C.
Nitrocellulose powders (U. S. A.)	32,365	2676°C.
Ballistite (nitroglycerine)	34,696	3384°C.

In view of the importance of the composition control, it is apparent that a great step in advance was made when mechanical mixtures such as gunpowder were replaced by explosive chemical compounds, such as nitrocellulose smokeless powders. The explosion of a powder in the breech of a gun for the purpose of throwing the projectile is essentially an action of rapid combustion, and is entirely different from the detonation characteristic of high explosives, such as nitroglycerine. If a propellant should detonate, it would be useless as a propellant and the detonation would doubtless rupture the gun without discharging the projectile. It is extremely important, therefore, in the manufacture of powders, that the element of detonation be entirely eliminated.

The most common form of smokeless powder is made by the treatment of cotton or some pure form of cellulose with a mixture of nitric and sulphuric acid, for the formation of a chemical compound known as nitrocel-

lulose. There are several kinds of nitrocellulose, grading from the lower degrees of nitration to the higher. The lower nitrocellulose compounds are known as soluble nitrocellulose, and form the combustible class of propellant explosives. The higher degrees of nitration give compounds known as guncotton, which are detonatable explosives. This latter class of compounds, however, is not soluble, and this difference gives a clear line of demarkation between those nitrocelluloses which are safe to use as propellant powders and the other class, which are used as detonatable explosives.

How Smokeless Powder Is Made.

The soluble nitrocelluloses are gelatinized by the use of various solvents, such as grain alcohol mixed with ether or with acetone. When the solvent is driven off a hard, bone-like mass is left, which is one of the forms of smokeless powder. The explosive pressure of these nitrocellulose gels may be increased by the addition of other constituents; for example, nitroglycerine is frequently used, especially in the specifications of England and France. Some of the powders now being used in Europe contain as high as 50 per cent. of nitroglycerine. Under ordinary conditions nitroglycerine is a highly detonatable explosive, but when incorporated in the nitrocellulose gel, it is reduced to a condition where it functions as a combustible propellant and is not detonatable.

The nitrocellulose gel is pressed into large cakes which are transferred to a squirting press, similar to that used for squirting macaroni. From this press it is squirted into continuous rods or fibers of any desired shape, cut up into short lengths, carefully dried to remove and recover the last traces of solvent, and then stored, ready for use.

Certain modifications in the formula, changes in the shape and size of the grains and other alterations are

made to meet the various military and sporting requirements. For example, the powder for the sixteen-inch coast defence guns comes in the form of pieces approximately five-eighths inch in diameter and two inches long, while a sample of the sporting powder is illustrated by fine grains the size of a mustard seed.

Stability is an important consideration in the manufacture of smokeless powder, and certain means have been developed which render them more stable and less liable to change or deterioration. One of the most important chemicals, used almost universally for this purpose, is di-phenyl-amine, and all smokeless powders contain approximately 1 per cent. of this chemical. Prior to August, 1914, practically all of the di-phenyl-amine used by all of the nations of the world was made in Germany and marketed through an English agency. Since the German supply has been cut off, the manufacture of this product has been developed in this country, and we are now able to supply our own needs.

High explosives, as a class, include all of those compounds and mixtures which are detonatable. They are used both in engineering practice and for military purposes as disruptive agents. In engineering work, the most common form of disruptive agent is dynamite, which is a mixture of nitroglycerine with some form of inert or active absorbent or carrier commonly known in the dynamite industry as "dope." The older forms of dynamite were made by soaking up the liquid nitroglycerine in infusorial earth, sawdust, wood fiber or some such absorptive material. In the more powerful dynamites the filler is also an explosive substance, such as cotton, ammonium nitrate and similar materials. Nitroglycerine, the basic explosive substance of dynamite, is made by the action of a mixture of sulphuric and nitric acid on glycerine. Glycerine, as you will recall, is a by-product of the soap industry and results from the treatment of a fat such as cottonseed oil, corn

oil, tallow, etc., with an alkali to form a soap and crude glycerine. The glycerine recovered from this operation is carefully refined and purified for the purpose of making nitroglycerine. One of the commercial grades is known as dynamite glycerine. Liquid nitroglycerine is an extremely dangerous explosive. Its danger lies in the fact that it is easily detonated and explodes with great violence. Its incorporation with some filler, after the inventions of Nobel, so that it may be treated and handled as a solid, minimized to a great degree the explosive danger. Dynamite could not, however, be used in any operations such as the filling of a shell, where it would be subjected to the severe shock of firing, without great danger of its detonating. As a consequence, it is not possible to use dynamite as a high explosive charge in artillery shells, whereas in engineering work it is a perfectly satisfactory and safe disruptive explosive.

Guncotton, that is to say, the higher degrees of nitration of ordinary cellulose, is also an easily detonatable explosive and cannot be used in any operations where it would be subjected to severe shock.

Nitroglycerine and guncotton are used in certain classes of war work, for bombs, charging of torpedoes, etc., where they are not subjected to rough handling or to the shock of being discharged from a gun.

Picric Acid.

High explosives for the charging of shells must necessarily be selected from substances which are detonatable by the use of a proper detonator, yet at the same time will not be detonated when subjected to the ordinary methods of military handling, and to the shock of being discharged from the gun. Detonatable explosives to meet those conditions are of comparatively recent origin. The oldest compound applied for this purpose is picric acid. The use of this substance

for loading shells was first suggested in 1886 by Turpin, in France. The compound itself has been well known for many years not as an explosive, but as one of the simplest forms of a yellow dyestuff. As a result of Turpin's investigations, picric acid has since been adopted in England under the name of Lyddite, in France under the name of Melinite, and the Japanese used the compound effectively in the Russo-Japanese war under the name of Shimose.

Picric acid is made by the treatment of phenol or carbolic acid with a mixture of sulphuric and nitric acid. The product, a yellow crystalline powder, is carefully purified and used either alone or with other explosive compounds for shell charges. It is melted and poured into the shells, leaving suitable space for the detonating cap. It is very stable to shock and the most powerful of the shell explosives of this class. It has some objectionable characteristics in that it is an acid and has a tendency to form salts which are unstable. Several fatal accidents have been traced to the formation of calcium and lead salts, which are especially sensitive. Notwithstanding these objections, however, picric acid has proved to be one of the most important and generally used explosives in the present war, and it is being manufactured both in this country and abroad in enormous quantities.

The phenol, or carbolic acid, from which picric acid is made is obtained under ordinary conditions from the distillation of coal-tar. The enormous demand for picric acid under war conditions has created a corresponding demand for phenol, and the price has advanced from 19 cents to $1.50 per pound. Phenol can be made and has been made for a number of years in Germany, synthetically, from benzol, another common constituent of coal-tar. In the manufacture of phenol the benzol is treated successively with sulphuric acid, lime, soda ash, caustic potash or soda, with the final

production of crude phenol. This crude phenol is carefully distilled in a vacuum and produces the chemically pure product, sample of which is shown. A large number of synthetic phenol plants have been started in the United States since the outbreak of the war in Europe, and chemical engineers have devoted a great deal of attention to the development of this industry in America.

T. N. T.

Another interesting high explosive for shells, and the one which is said to have been so effective in the reduction of the forts at Liege, is tri-nitro-toluol, commonly known as T.N.T. This product is made by the nitration with a mixture of sulphuric and nitric acid, of toluol, another liquid constituent of coal-tar. The increased demand for toluol has run the price from 40 cents a gallon before the war to as high as $5 or $6 a gallon. Numerous processes have been more or less successfully developed for the manufacture of toluol. One of the most important of these is our own Rittman process, which is in successful operation in Pittsburgh, manufacturing a mixture of toluol and benzol.

T.N.T. is a light yellowish solid, very stable to shocks and abrasions, and is in every way an ideal disruptive explosive, although not quite so powerful as picric acid. It is non-acid and does not form unstable compounds. It is practically impossible to explode a charge of T. N. T. except by the use of powerful detonators.

Detonators are a class of compounds which explode with extreme violence and sharpness. On account of their sharp explosive wave, they have the power of setting up a corresponding explosive wave in a large number of otherwise more or less stable substances, such as trinitrotoluol and picric acid, and with fair ease such substances as nitroglycerine and gun-cotton. The class of compounds known as metallic fulminates

are commonly used as detonators. The most important of these is the fulminate of mercury. This product is made by the action of nitric acid and alcohol on mercury. It is a grayish white crystalline powder and is stored for safety in small bags suspended in a tank of water. It detonates by shock, as, for example, by the firing pin of a gun, or by heat of approximately 200 deg. C., as by a fuse. Small charges of these detonators are imbedded in the main explosive charge, and the sharp shock of their explosion detonates the entire mass. It should also be noted that by the use of these detonators it is possible to explode the shell either by a time fuse or by impact, and both methods are used according to the character of the operation.

How to Stop the War.

You have doubtless noticed that the same chemicals are used in some phase or other, in each one of the processes of manufacturing high explosives, and smokeless powders. I refer particularly to the use of sulphuric acid and nitric acid. Sulphuric acid is doubtless the most important of these, because it is essential not only in making all explosives, but in the manufacture of nitric acid itself. Sulphuric acid may be said, therefore, to be the basic chemical on which the entire war is dependent, and there is nothing which would more effectively stop a war than to stop the production of sulphuric acid. The raw materials for making sulphuric acid are, (1) sulphur, or (2) pyrites, or (3) sulphur gases from smelting operations. The sulphur used in America comes from the deposits in Louisiana and Texas, where it literally flows from the earth at the rate of 500 to 1000 tons per day by the famous Frasch process. The pyrites, while produced to a small extent in this country, comes largely from Spain or Portugal. The smelter gases are necessarily available only at the points where the smelting opera-

tions are carried out. It is obvious that we would be seriously handicapped in case the Spanish pyrites supply was cut off, and it is even more serious to note that the sulphur deposits of Louisiana and Texas are both near the coast and are undefended. The loss of control of these two principal raw materials for sulphuric acid manufacture would literally put a stop to ammunition production in this country.

Chemical Preparedness.

Another fundamental raw material of the explosive industry is nitric acid, which is obtained from nitrate of soda, the sole source of supply of which, for this country, is Chili. No progress has been made, and very little if any interest has been shown in the development of an independent self-contained source of supply for nitrates or nitric acid in America. It is clearly apparent that a few fast cruisers could cut off our supply of nitrate, and the stock available in this country would not enable us to carry on a defensive war more than two or three months. One might naturally ask, what is being done to safeguard this country against such a contingency, and the answer is, nothing.

The previous speaker referred to certain influences which appear in diplomatic dealings, but it is my belief that one of the most potent influences in a successful diplomacy is to be found in the adequate and intelligent solution of some of the problems presented in connection with the industries now under discussion. One of our statesmen has declared that an army of a million men might be provided in a few days, but what earthly good would a million men be if they are not provided with the modern facilities and machinery for conducting a defense. The most apparent lesson to be drawn from the conditions in Europe is that there is a great deal in an army besides men. The fact that the power of defence in the United States could be

rendered ineffective in two or three months by a few warships stopping the supply of nitrate from Chili, taking possession of the sulphur deposits of Louisiana and Texas, and crippling other important industrial centers, is well known in every capital in Europe, and such knowledge does not tend to add force nor emphasis to our diplomatic notes.

Germany has clearly indicated the solution of the nitrate problem. She has been cut off from the nitrate supply of Chili and from the pyrites supply from Spain for months, but long before that condition developed, she had worked out and put into operation within her own borders processes for manufacturing nitric acid synthetically. This result is accomplished in Germany by three important industrial processes which have been developed within the last ten or fifteen years: (1) The process for the direct oxidation of the nitrogen of the air, (2) the process of oxidizing ammonia made by the Haber method of combining nitrogen and hydrogen, in the presence of catalytic agents, and (3) another process oxidizing ammonia made by the syanamid process, in which the nitrogen of the air is fixed in calcium carbide, and later converted into ammonia. The power of Germany would have been broken months ago, had it not been for the foresight and the skill required to provide an independent supply of the fundamental chemicals required in explosive manufacture."

APPLICATIONS.

Military Explosives.

Of these explosives, *black powder* will seldom be available and therefore will be little used.

Gun-cotton is powerful and efficient, but will not be available unless carried along. Dry gun-cotton is very sensitive, and therefore dangerous to transport, so that

in carrying this explosive an additional weight of 20 to 25 per cent. of water must be carried, this being about the degree of saturation required to make it safe. A small quantity of dry gun-cotton must also be carried, as this is the only satisfactory primer for the wet material. The dry charge is fired by the ordinary fulminate primer.

Rack-a-rock has the advantage of perfect safety in transportation, being composed of two substances, neither of which is explosive. Powdered chlorate of potash is put up in cloth bags the size of a dynamite cartridge. These are soaked in mono-nitrobenzol, allowed to drain for a minute, and then may be primed and fired similarly to dynamite. This explosive, also, must be carried to be available in the field.

Trinitro-toluol is perfectly safe for any character of transportation, being inert to physical shock, and is detonated only by a powerful fulminate cap. It comes in three forms, the natural granular substance in paper cartridges, the TNT blocks into which it is pressed for the U. S. Engineers, and *trotol gelatine,* the preparation of Capt. Woodward of the 22nd Corps of Engineers. This substance is very powerful, quick detonating and shattering. It has not the noxious fumes of dynamite, will not freeze, and is insensitive to shock. Its great disadvantage lies in the fact that, like gun-cotton and rack-a-rock, it must be carried to be available when desired.

The well-known *dynamite,* reliable when handled carefully, available at any country store, and familiar to nearly every engineer and foreman, will probably form the bulk of the explosive used by the army in the field.

Firing Charges.

These explosives, with the exception of black powder, are of the detonating variety, and may be exploded by

means of the fulminate cap, either by fuse or by electricity. The former is of two varieties, *Bickford,* which is *white,* has a *twisted* surface, and burns at the rate of *two* feet per minute, and the *Instantaneous* fuse, which is *red,* has a rather smooth, *woven* surface, and burns at the rate of about 120 feet per *second.* Electric ignition is preferable, as the time of firing is under the control of the operator and a number of charges may be fired simultaneously. When it is required to fire several charges simultaneously by fuse, a length of instantaneous fuse should be connected to the primer of each charge, and the various free ends gathered into a small bag of powder. This is ignited by a piece of Bickford fuse, cut long enough to allow the escape of the powder man.

Demolition by Explosives.

The most important demolitions affect lines of communication, and must not be undertaken except as a matter of military necessity and under positive written orders from the commander of the field forces. Large bridges are attacked in the chords, near the abutments where the chord sections are smallest. All longitudinal members should be cut. Arches are cut at the crown if single, or if double, at the pier between them. Trees not over a foot in diameter may be felled by firing a charge in the shape of a chain of dynamite cartridges encircling their trunks. Twenty per cent. of this amount will have the same effect if placed in a hole bored in the trunk. Used in this latter way, one stick of 40 per cent. dynamite will cut about one square foot of timber.

Railroad track is best destroyed by *mud-capping* four charges of about one stick each against the rail flanges, so as to cut each rail in two places. The section of track is then turned over, the ties pried off and

a bonfire made of them. The rails are heated in the fire and *twisted,* using pincers, crowbars through the splice-bolt holes, or any manner of gripping the rail firmly. Rails thus twisted cannot be used again until re-rolled, whereas if they are simply bent around a tree, they may be roughly straightened in the field. If it be desired to destroy the track without permanent damage to the material, the fish-plates may be taken off at the ends of a long section, the loosened portion lifted by a large force of men and rolled down the embankment. It must be remembered that unless the demolition be most thorough, good railway troops can repair track about as rapidly as it can be destroyed.

Small bridges, intended to be demolished as soon as the immediate need for them has passed, are usually prepared for demolition during construction, so that the charges may be fired when the last troops have crossed, and before a closely pursuing enemy can follow.

Fig. 41 shows the placing of a charge of rack-a-rock

FIG 41. PLACING CHARGE

in a spar bridge, Fig. 42 the explosion, and Fig. 43 the destroyed bridge.

FIG. 42. THE EXPLOSION

FIG. 43. BRIDGE DESTROYED

For the destruction of woods, villages, etc., which must be razed to give a clear field of fire, explosives will not be wasted unless great haste is required. Free use of the axe, and the assistance of troops from the infantry, will accomplish much in a short time. If the smoke is not objectionable as betraying the position, this work may be done largely by means of fire.

XII.

MILITARY BRIDGES.

Military bridges are of many types. From the felled log that may enable a single messenger to cross with an important order, to the railway trestle that carries the supply trains, all sorts and sizes of bridges find their application to military purposes. Outside of certain improvised types, however, and others that are little used, military bridges may be grouped in four general classes: truss, pile, spar and floating. *Truss bridges* find their principal application along the line of communications and will be little used at the front.

Loads.

The loads which military bridges will have to support are about as follows, in pounds per *linear* foot of bridge:

Infantry,	single file, heavy marching order	140	pounds
"	double file, " " "	280	"
"	col. of fours " " "	560	"
Cavalry,	single file	196	"
"	double file	392	"
"	column of fours	784	"

WEIGHTS OF GUNS AND MILITARY CARRIAGES, FULLY LOADED FOR TRAVELING. *

	Weight on the Wheels. Front Lbs.	Hind Lbs.	Distance between Axles, c. to c. Ft.	Ins.	Width of wheel Track, c. to c Ft.
3.2-in. B. L. F. gun	1,735	2,070	8	7	5
3.6-in. B. L. F. gun	1,870	2,415	8	9	5
3.2-in. caisson	1,775	2,805	8	5¾	5
3.6-in. caisson	1,930	3,070	8	6	5
Battery and forge wagon	1,130	2,130	8	6	5
5-in. siege rifle	2,530	6,425	8	1¼	5
7-in. siege howitzer	2,510	6,920	8	1¼	5
Maxim automatic	1,950	1,230	7	0	5
Gatling	754	1,075	7	0	5
Army escort wagon (4 mules)	2,500	2,500	5	9½	5
Army wagon (6 mules)	3,500	3,500	6	1½	5

*From Engineer Field Manual.

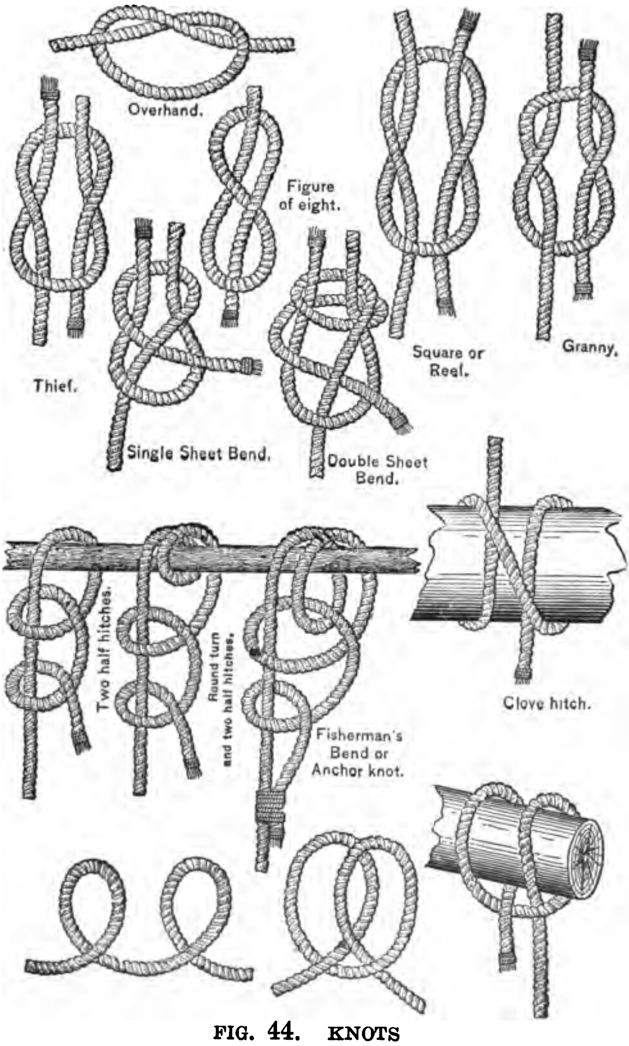

Overhand.
Figure of eight.
Thief.
Single Sheet Bend.
Double Sheet Bend.
Square or Reef.
Granny.
Two half hitches.
Round turn and two half hitches.
Fisherman's Bend or Anchor knot.
Clove hitch.

FIG. 44. KNOTS

Knots and Lashings.

A knowledge of a number of the common knots, splices and lashings is essential to the construction of military bridges, particularly those of the spar type. Those described herein are taken from the Engineer Field Manual:

The following knots are most useful in bridging.

Overhand knot, used at the end of a rope to prevent unreeving or to prevent the end of the rope from slipping through a block.

Figure-of-eight knot, used for purposes similar to above.

Square or *reef knot,* commonly used for joining two ropes of the same size. The standing and running parts of each rope must pass through the loop of the other in the same direction, i. e., from above downward or vice versa; otherwise a *granny* is made, which is a useless knot that will not hold. The reef knot can be upset by taking one end of the rope and its standing part and pulling them in opposite directions. With dry rope a reef knot is as strong as the rope; with wet rope it slips before the rope breaks, while a double sheet bend is found to hold.

The *thief knot,* commonly mistaken for a reef knot, should be avoided as it will not hold. The figure shows that the end of each rope turns around the standing part instead of around the end of the other, as in a reef knot.

Single sheet bend, weaver's knot, used for joining ropes together, especially when unequal in size. It is more secure than the reef knot but more difficult to untie.

Double sheet bend, used also for fastening ropes of unequal sizes, especially wet ones, and is more secure than the single sheet bend.

Two half hitches, especially useful for belaying, or

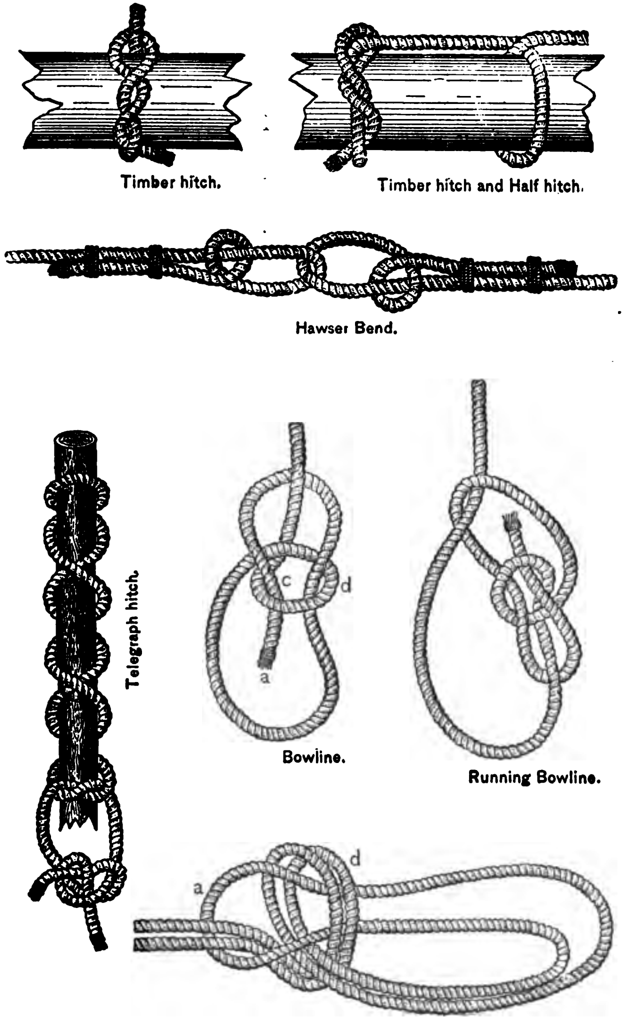

Timber hitch.
Timber hitch and Half hitch.
Hawser Bend.
Telegraph hitch.
c
d
a
Bowline.
Running Bowline.
d
a

FIG. 45. KNOTS

making fast the end of a rope round its own standing part. The end may be lashed down or seized to the standing part with a piece of spun yarn; this adds to its security and prevents slipping.

This knot should never be used for hoisting a spar.

Round turn and *two half hitches,* like the preceding except that a turn is first taken round the spar or post.

Fisherman's bend or *anchor knot,* used for fastening a rope to a ring or anchor. Take two turns round the iron, then a half hitch round the standing part and between the rings and the turns, lastly a half hitch round the standing part.

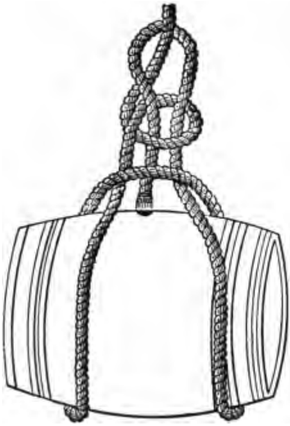
Clove hitch, generally used for fastening a rope at right angles to a spar or at the commencement of a lashing. If the end of the spar is free, the hitch is made by first forming two loops, placing the right-hand loop over the other one and slipping the double loop over the end of the spar. If this can not be done, pass the end of the rope round the spar, bring it up to the right of the standing part, cross over the latter, make another turn round the spar, and bring up the end between the spar, the last turn, and the standing part. When used for securing guys to sheer legs, etc., the knot should be made with a long end, which is formed into two half hitches round the standing part and secured to it with spun yarn.

Timber hitch, used for hauling and lifting spars. It can easily be loosed when the strain is taken off, but will not slip under a pull. When used for hauling spars, a half hitch is added near the end of the spar.

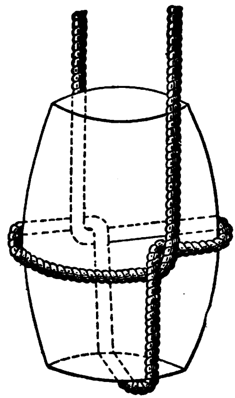
Telegraph hitch, used for hoisting or hauling a spar.

Hawser bend, used for joining two large cables. Each end is seized to its own standing part.

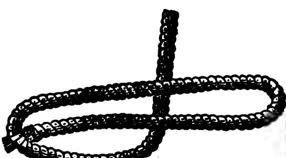
Bowline forms a loop that will not slip. Make loop with the standing part of the rope underneath, pass the end from below through the loop, over the part round the standing part of the rope, and then down



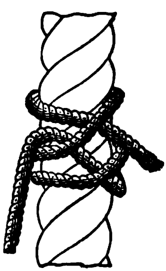
Sling for barrel horizontal.



Sling for barrel vertical.



Cat's Paw. a.



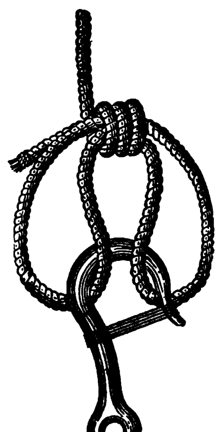


FIG. 46. KNOTS

through the loop *c*. The length of bight depends upon the purpose for which the knot is required.

Bowline on a bight. The first part is made like the above, with the double part of a rope; then the bight *a* is pulled through sufficiently to allow it to be bent past *d* and come up in the position shown. It makes a more comfortable sling for a man than a single bight.

Running bowline. A slip noose formed by a bowline running on the standing part of the line.

Barrel Sling. To sling a barrel or box horizontally, make a bowline with a long bight and apply it as shown.

To sling a barrel vertically, make an overhand knot on top of the two parts of the rope; open out the knot and slip each half of it down the sides of the cask; secure with a bowline.

Cat's-paw. Form two equal bights. Take one in each hand and roll them along the standing part till surrounded by three turns of the standing part; then bring both loops (or bights) together and pass over the hook of a block.

Sheep shank, used for shortening a rope or to pass by a weak spot; a half hitch is taken with the standing parts around the bights.

Rolling hitch, used for hauling a large rope or cable. Two turns are taken round the large rope in the direction in which it is to be hauled, and one half hitch on the other side of the hauling part. A useful knot and quickly made.

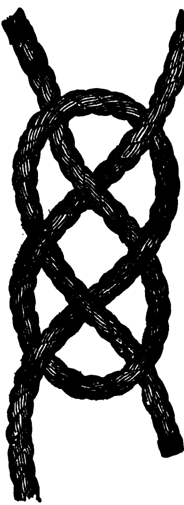
For armored cable, or wet manila rope, the hitch must be made with a strap of rope yarn. Rope will not hold.

Blackwall hitch, used for attaching a single rope to a hook of a block for hoisting.

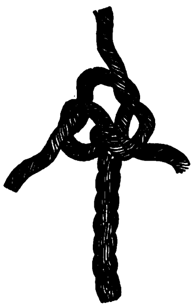
Mooring knot. Take two turns round the mooring or snubbing post, pass the free end of the rope under the

Blackwall Hitch.

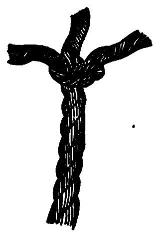
Mooring Knot.



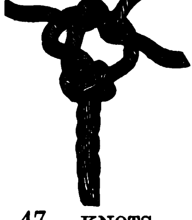
Carrick Bend.



Wall Knot.



Wall Knot.



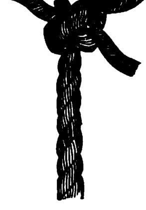


FIG. 47. KNOTS

standing part; take a third turn above the other and pass the free end between the two upper turns.

Carrick bend, much used for hawsers and to fasten guys to derricks.

Wall knot, and

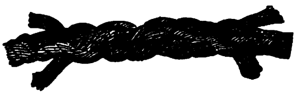
Crown on wall, both used for finishing off the ends of ropes to prevent unstranding.

To make a *short splice,* unlay the strands of each rope for a convenient length. Bring the rope ends together so that each strand of one rope lies between the two consecutive strands of the other rope. Draw the strands of the first rope along the second and grasp with one hand. Then work a free strand of the second rope over the nearest strand of the first rope and under the second strand, working in a direction opposite to the twist of the rope. The same operation applied to all the strands will give the result shown in Fig. 48. The splicing may be continued in the same manner to any extent and the free ends of the strands may be cut off when desired. The splice may be neatly tapered by cutting out a few fibers from each strand each time it is passed through the rope. Rolling under a board or the foot will make the splice compact.

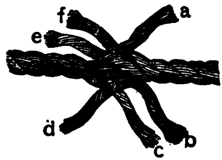
Long splice. Unlay the strands of each rope for a convenient length and bring together as for a short splice. Unlay to any desired length a strand, *d,* of one rope, laying in its place the nearest strand, *a,* of the other rope. Repeat the operation in the opposite direction with two other strands, *c* and *f.* Strands *b* and *e* are shown secured by unlaying half of each for a suitable length and laying half of the other in place of the unlayed portions, the loose ends being passed through the rope. This splice is used when the rope is to run through a block. The diameter of the rope is not enlarged at the splice. The ends of the strands should not be trimmed off close until the splice has been thoroughly stretched by work.

Short Splice.

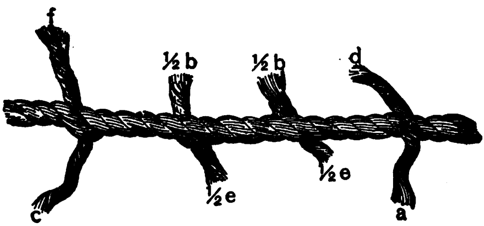
Short Splice



Short Splice.



Long Splice.



Long Splice.

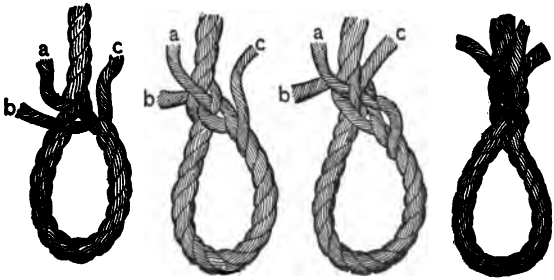


FIG. 48. KNOTS

Eye splice. Unlay a convenient length of rope. Pass one loose strand, *a,* under one strand of the rope, forming an eye of the proper size. Pass a second loose strand of the rope next to the strand which secures *a.* Pass the third strand, *c,* under the strand next to that which secures *b.* Draw all taut and continue and complete as for a short splice.

To *lash a transom to an upright spar,* transom in front of upright, a clove hitch is made round the upright a few inches below the transom. The lashing is brought under the transom, up in front of it, horizontally behind the upright, down in front of the transom and above the clove hitch. The following turns are kept outside the previous ones on one spar and inside on the other, not riding over the turns already made. Four turns or more are required. A couple of frapping turns are then taken between the spars, around the lashing, and the lashing is finished off either round one of the spars or any part of the lashing through which the rope can be passed. The final clove hitch should never be made around the spar on the side toward which the stress is to come, as it may jam and be difficult to remove. The lashing must be well beaten with handspike or pick handle to tighten it up. This is called a square lashing.

Lashing for a pair of shears. The two spars for the shears are laid alongside of each other with their butts on the ground, the points below where the lashing is to be resting on a skid. A clove hitch is made round one spar and the lashing taken loosely eight or nine times about the two spars above it without riding. A couple of frapping turns are then taken between the spars and the lashing is finished off with a clove hitch above the turns on one of the spars. The butts of the spars are then opened out and a sling passed over the fork, to which the block is hooked or lashed, and fore and back guys are made fast with clove hitches to the bot-

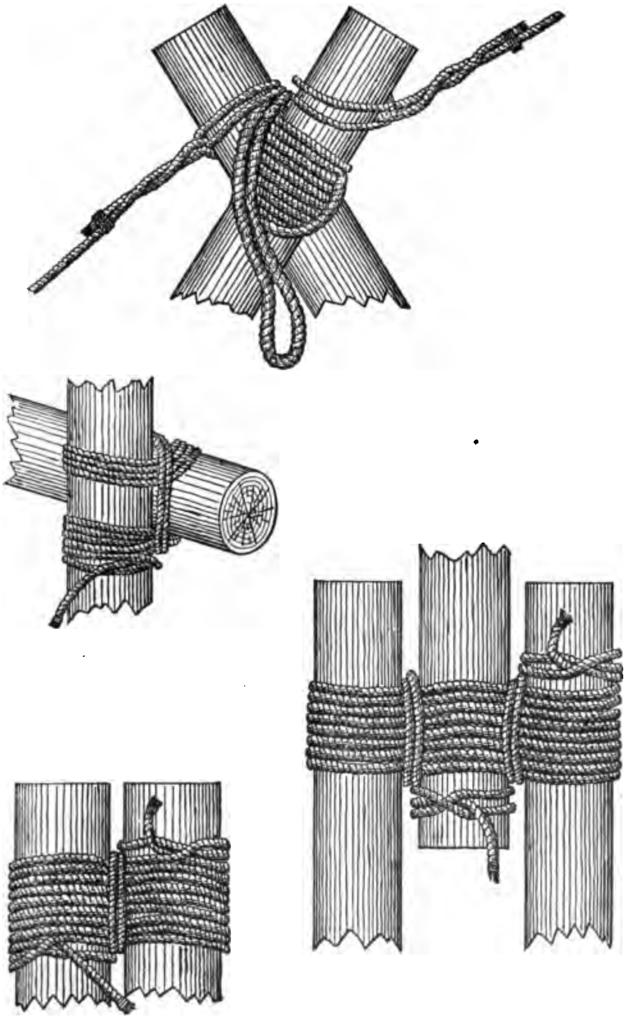


FIG. 49. LASHINGS

tom and top spars, respectively, just above the fork. (Top of Fig. 49).

To lash three spars together as for a gin or tripod. Mark on each spar the distance from the butt to the center of the lashing. Lay two of the spars parallel to each other with an interval a little greater than the diameter. Rest their tips on a skid and lay the third spar between them with its butt in the opposite direction so that the marks on the three spars will be in line. Make a clove hitch on one of the outer spars below the lashing and take eight or nine loose turns around the three. Take a couple of frapping turns between each pair of spars in succession and finish with a clove hitch on the central spar above the lashing. Pass a sling over the lashing and the tripod is ready for raising.

To prepare a fastening in the ground for the attachment of guys or purchases, stout pickets are driven into the ground one behind the other, in the line of pull. The head of each picket except the last is secured by a lashing to the foot of the picket next behind. The lashings are tightened by rack sticks, the points of which are driven into the ground to hold them in position. The distance between the stakes should be several times the height of the stake above the ground.

Another form requiring more labor but having much greater strength is called a *deadman,* and consists of a log laid in a transverse trench with an inclined trench intersecting it at its middle point. The cable is passed down the inclined trench, takes several round turns on the log, and is fastened to it by half hitches and marlin stopping. If the cable is to lead horizontally or inclined downward, it should pass over a log at the outlet of the inclined trench. If the cable is to lead upward this log is not necessary, but the anchor log must be buried deeper.

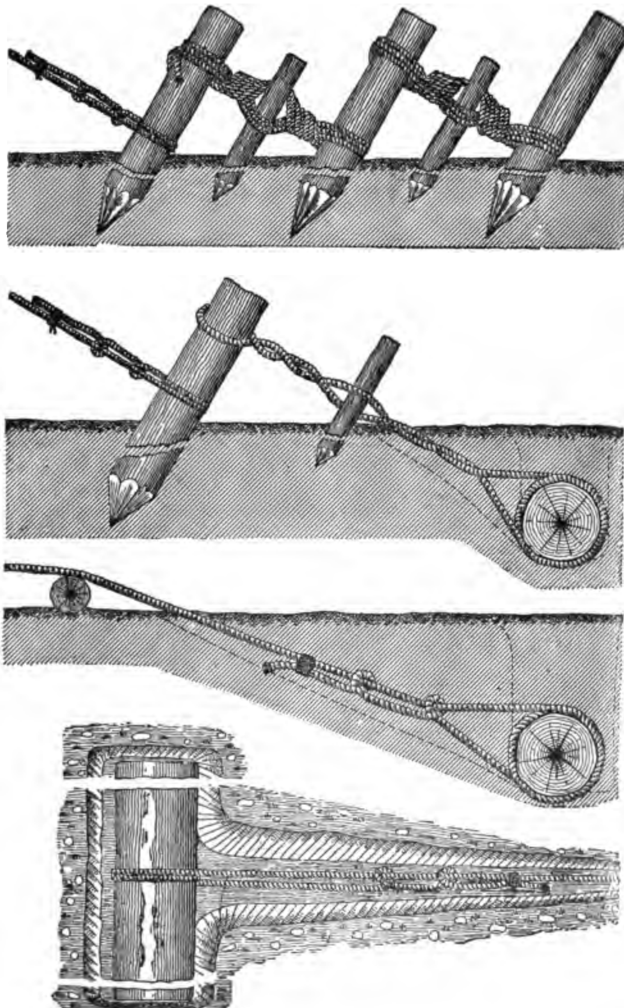


FIG. 50. GROUND TACKLE

Improvised Bridges.

Suspension bridges are sometimes built, but are not generally satisfactory as a field type, owing to their lack of stiffness. With the labor necessary to properly construct such a bridge, with an adequate stiffening truss, a more serviceable truss or pile bridge might be built. However, where the material at hand and the locality are particularly suited to a suspension bridge, there should be no hesitancy in undertaking its construction. The towers may be lashed spar bents, the anchorages *deadmen,* the cable steel wire rope, the suspenders of wire, and the floor system of round timber or ponton material. If a stiffening truss is used, it will probably be of the Howe or Pratt type of bracing, with timber struts and twisted wire diagonals.

An excellent foot suspension bridge may be made from Page woven wire fencing, three lengths being used, one for the bottom and one for each side. The sides may be wrapped around convenient trees or well braced vertical posts and firmly fastened with staples. The bottom is fastened in a similar manner to a log which is staked back of the supporting trees. The floor beams are round or square timbers resting on the bottom wires of the sides and the outer wires of the bottom section of fencing. Floor boards may be nailed or lashed longitudinally to the floor beams, or placed transversely upon stringers resting on the beams. Such a bridge is good for a span of 150 or more feet, can be constructed in an hour if the materials are at hand, and will bear fully equipped infantrymen at intervals of four or five feet. The sag should be about one-tenth of the span.

When only a number of short boards are available for a bridge, as for instance those obtained from packing cases, a sort of latticed girder truss is sometimes built by nailing them together to form chords and diagonals. Similar material is also made into a bowstring

FIG. 51. FLOATING PILE-DRIVER

truss, the chords being formed of boards set on edge, inclosing the ends of the web members. These bridges must be considered as expedients only and not as accepted military types.

Pile Bridges.

Pile bridges will probably be the most used. The piles will be driven by hand mauls or by a field pile driver such as shown in Fig. 51. Here the platform is formed of the ponton material, the leads are ponton floor stringers, the hammer a section of tree trunk, and it is operated by man power. A similar driver is built to rest upon the completed portion of a bridge, cantilevering out to the bent under construction. The outer

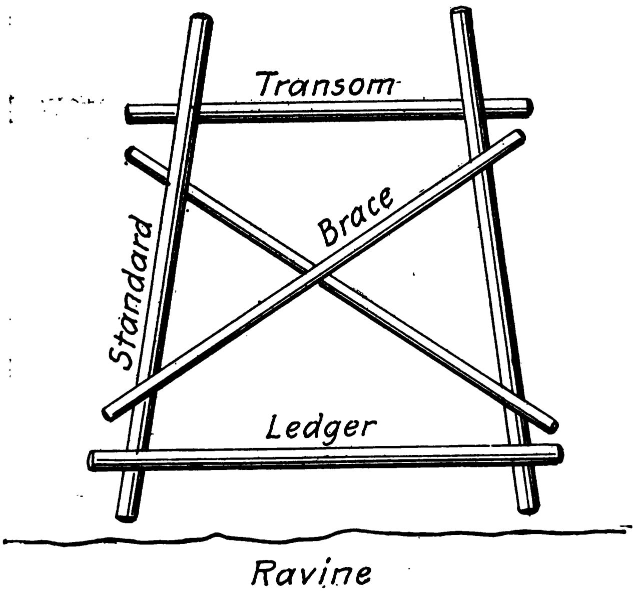


FIG. 52. TRESTLE FOR SPAR BRIDGE

end is trussed up by twisted ropes, passing from the bottom of the leads, over king posts, and down to the rear end of the driver, which is counterweighted by logs or sand bags. The floor of the completed bridge is of plank if available, or caps, stringers, floor and guard timbers may all be of round stuff, laid *corduroy* style.

Spar Bridges.

Spar bridges are in a distinct class by themselves. They have been developed solely by military engineers, and their great advantage lies in the fact that they may be constructed entirely of rough timber, cut at the site, and put together by means of rope lashings. A stream or ravine with steep banks and of no great width is particularly suited for a spar bridge.

Single lock bridge. A trestle as shown in Fig. 52 is built upon each bank, the top of one being made of a

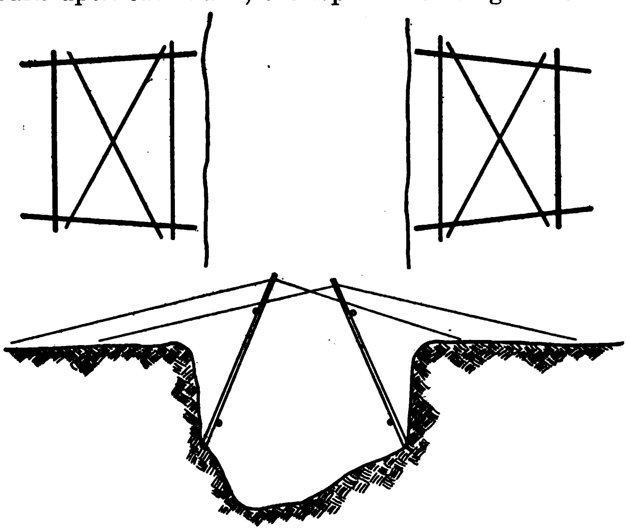
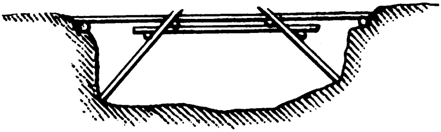


FIG. 53. ERECTION OF SPAR BRIDGE

FIG. 54. SINGLE LOCK BRIDGE TRESTLES LOCKED

width to pass readily between the standards of the other. (Fig. 53.) The two are then lowered into the ravine and their transoms locked. (Fig. 54.) A *road-bearer* is placed in the fork of the standards, and forms a support in the middle of the span. In a *double lock* bridge (Fig. 55) the trestles do not interlock, but are held apart by two road bearers, lashed to two


Double Lock Bridge.

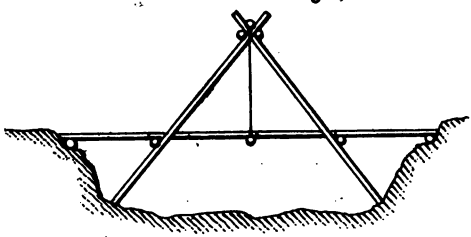

Single Sling Bridge

FIG. 55. DOUBLE LOCK AND SINGLE SLING BRIDGES

stringers which rest upon the transoms of the trestles. The bridge thus has *two* supports and *three* panels.

Single Sling Bridge. If the standards of a double lock bridge are extended to a junction above the center of the bridge (Fig. 55), an additional road bearer or floor beam may be suspended from the intersection, and the number of panels increased to *four*. *Double sling* and *triple sling* bridges have been constructed, but the single sling is practically the limit of development of the spar bridge. A sling bridge requires much heavier standards than the double-lock type. Fig. 56 shows a spar bridge of the double lock type.

FIG. 56. DOUBLE LOCK BRIDGE COMPLETED

ROUND TIMBER REQUIRED FOR SPAR BRIDGES.

Kind of bridge.	Spars.	Length.	Diameter. At tip.	Diameter. Throughout or mean.	Purpose.
	No.	Ft.	Ins.	Ins.	
Single lock, 30-ft. span.	4	22	7	.	Standards.
	2	15	.	6	Transoms.
	4	15	.	4 to 6	Ledgers and shore trans.
	4	20	.	3	Diag. braces.
	1	15	.	10	Fork trans.
	10	20	.	6	Balk.
	4	20	.	3 to 6	Side rails.
Double lock, 45-ft. span	4	20	7	.	Standards.
	2	15	.	6	Main trans.
	4	15	.	4 to 6	Ledgers and shore trans.
	2	25	.	8	Distance pcs.
	2	15	.	10	Road trans.
	4	20	.	3	Braces.
	15	20	.	6	Balk.
	4	20	.	4 to 6	Side rails.

From Engineer Field Manual.

ROPE REQUIRED FOR SPAR BRIDGES.

Description and size of ropes.	Single lock.			Double lock.		
	Ropes.	Total length.	Max. wt.	Ropes.	Total length.	Max. wt.
	No.	Ft.	Lbs.	No.	Ft.	Lbs.
Foot ropes, 3 in. circ., 40 to 60 ft.	4	240	71	4	240	71
Guys, 3 in. circ., 120 to 150 ft.	8	1,200	356	8	1,200	356
2 in. circ., 108 ft.	2	216	29	2	216	29
1½ in. circ., 54 ft., for transom lashings	4	216	29	8	512	68
1½ in. circ., 36 ft., for ledger and brace lashings	10	360	27	14	504	37
1 in. circ., 21 ft., for road bearers	10	210	7	10	210	7
Spun yarn	..	..	7	..	..	7
Aggregate length and weight of rope required	..	2,442	526	..	2,882	575

From Engineer Field Manual.

For bridging a shallow ravine or watercourse, some one of the following lashed trestle bridges is applicable:

The *Two Legged Trestle* consists of a lashed frame as used for a single lock bridge, the standards being set at a greater slope. Each trestle is assembled on shore, carried out to the head of the completed bridge and let down by inclined skids until its feet are in position. The top is then pushed out by means of the stringers, previously lashed to the transom, the flooring is completed out to this point, the skids placed in position, and another trestle brought out and placed. See bottom of Fig. 57.

The *Three Legged Trestle* contains bents of two tripods each. The three legs of a tripod are lashed together at the top by means of two *shear lashings,* three ledgers are lashed around the bottom to keep the legs spread, and a transom is lashed on the inside face of each tripod. The road bearer rests upon the two

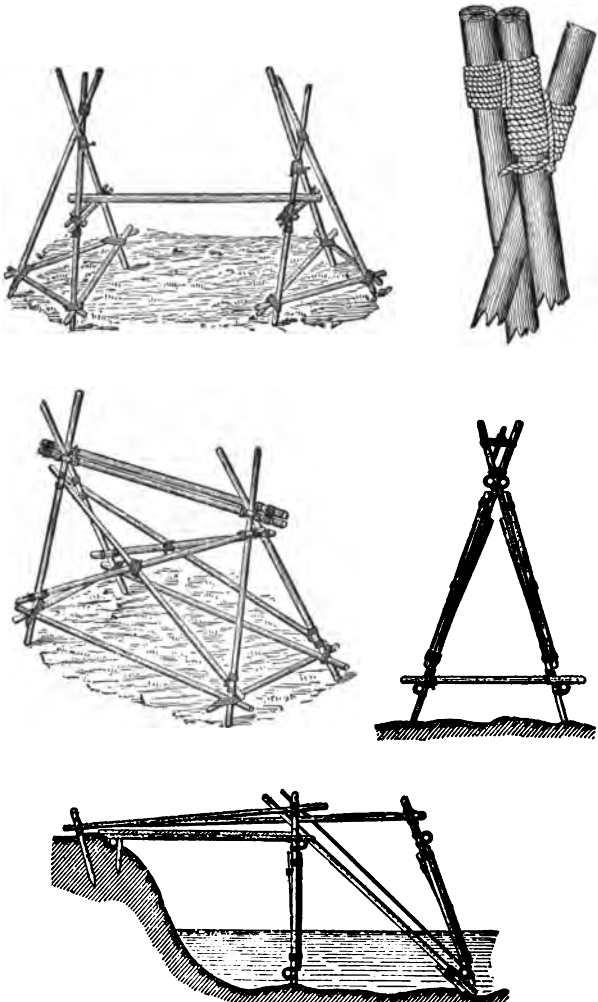


FIG. 57. LASHED TRESTLE BRIDGES

transoms. This type is built in place, the men wading in the water. It is impracticable in deep water, as the tripods are liable to float before the load is placed upon them. See top of Fig. 57.

The *Four Legged Trestle* is constructed in place, or, if of light spars, it may be carried out and placed in position. See Fig. 57, center cut.

SPARS AND LASHINGS FOR TRESTLES.

Kind of trestle.	No. of spars or lashings.	Length.	Diam. of spars or circ. of rope.	Purpose.
		Ft.	Ins.	
Two-legged	2	....	4½ to 6	Legs.
	1	10 to 14	5¾ to 7	Transom.
	2	....	3½ to 4½	Diagonals.
	1	....	3 to 6	Ledger.
	6	30	1½	Lashings.
	3	15	1½	Lashings.
Three-legged	6	....	3 to 5	Legs.
	1	14	7 to 8	Transom.
	4	4 to 6	3 to 3½	Cross bearers.
	6	6	1¾ to 2½	Ledgers.
	4	2	2	Stakes.
	12	30	1½	Lashings.
	6	15	1½	Lashings.
Four-legged	4	....	3¼ to 4¾	Legs.
	2	10 to 14	5 to 6	Transom.
	4	....	3 to 3½	Diagonals.
	4	....	2½ to 3	Ledgers.
	12	30	1½	Lashings.
	6	15	1½	Lashings.

From Engineer Field Manual.

Floating Bridges.

Floating bridges are among the most important equipment carried by an army in the field. The equipage of the U. S. Army is of two kinds: the advance guard or light train, and the reserve or heavy train.

The *Light Train* is generally carried by engineers with the advance guard. The boats are collapsible, of wooden frames covered with canvas, and displace 6

tons. Each will carry 20 infantrymen fully equipped, and a crew. The boats are 21 ft. x 5 ft. 4 in. x 2 ft. 4 in., are spaced 16 feet center to center in the bridge, and the entire boat, with material for one *bay* or panel of the floor, is carried on one wagon. A division of the light train comprises eight boats and two trestles, spans 186 feet, and is carried upon 14 wagons, 8 ponton, 2 trestle, 2 chess, 1 tool, and 1 battery and forge.

The *Heavy Train* consists of wooden boats, 31 ft. x 5 ft. 8 in. x 2 ft. 7 in., displacing 9½ tons, and capable of carrying 40 infantrymen and a crew. They are spaced 20 feet apart, center to center, in the bridge, and one wagon carries a boat with the stringers for spanning one bay. A division of the reserve train comprises 8 boats and 2 trestles, spans 225 feet, and is carried upon 16 wagons, 8 ponton, 2 trestle, 4 chess, 1 tool and 1 battery and forge. Fig. 58 shows a loaded ponton carriage of the reserve train.

FIG. 58. LOADED PONTON CARRIAGE, RESERVE TRAIN

The *Floor System* consists of long stringers or *balks* which span between and across both boats, the *chess,*

which form the floor, and the *side rails*, which are extra balks laid on the outer ends of the chess to keep them down. The side rails are lashed to the balks under the chess, the latter being made narrower at the ends to allow passing the lashing between them. The floor is designed to fail before the boats can be sunk by a load on the bridge, and will safely carry 660 pounds per linear foot in the reserve equipage and 600 pounds in the light. Greater strength is obtained by using extra balk under the wheel tracks, and the factor of safety of the boats may thus be reduced from 4 to 2. Any load which travels with the army, including siege artillery, may then pass over the bridge.

NAMES AND DIMENSIONS OF THE PRINCIPAL PARTS OF THE LIGHT AND HEAVY TRAINS.

Name of part.	Light train.	Heavy train.
Ponton, 9½ ton...	....	31 ft. by 5 ft. 8 in. by 2 ft. 7 in.
Canvas ponton, 6 tons	21 ft. by 5 ft. 4 in. by 2 ft. 4 in.	
Balks and side rails	22 ft. by 4½ by 4½ in.	27 ft. by 5 by 5 in.
Trestle balks	....	21 ft. 8 in. by 5 by 5 in.
Chess	11 ft. by 12 by 1½ in.	13 ft. by 12 by 1½ in.
Abutment sills	....	14 ft. by 8 by 6 in.
Trestle caps, 2 planks each	....	20 ft. by 12 by 2 in.
Trestle legs	....	15 ft. by 7 by 3½ in.
Trestle shoe	....	
Suspension chains.	....	½ in. by 8 ft.
Paddles	8 ft.	
Oars	....	18 ft.
Boat hooks	8ft., blunted points	10 ft.
Rack sticks	1¼ in. diam. 2 ft. long	1¼ in. diam., 2 ft. long.
Anchor	75 lb.	150 lb.
Anchor cable	3 in. circ., 180 ft. long	3 in. circ., 240 ft. long.

Name of part.	Light train.	Heavy train.
Lashings	1 in. circ., 18 ft. long	1 in. circ., 18 ft. long.
Canvas-ponton cover.....	No. 0000 cotton duck	
Ponton chest	8 ft. long, 2 ft. 4 in. wide, 18 in. deep	

From Engineer Field Manual.

WEIGHTS OF WAGONS AND THEIR LOADS.

Kind of wagon.	Light train.			Heavy train.		
	Wagon. Lbs.	Load. Lbs.	Total. Lbs.	Wagon. Lbs.	Load. Lbs.	Total. Lbs.
Ponton	1,750	1,985	3,735	2,200	2,900	5,100
Chess	1,750	1,856	3,606	1,750	2,280	4,030
Trestle	1,750	2,060	3,810	2,200	2,635	4,835
Tool	1,700	1,938	3,638	1,700	2,100	3,800
Battery and forge	2,081	600	2,681	2,081	600	2,681

From Engineer Field Manual.

To save one boat at either end, and in places where a boat would ground, the *Birago Trestle* (Fig. 59) is

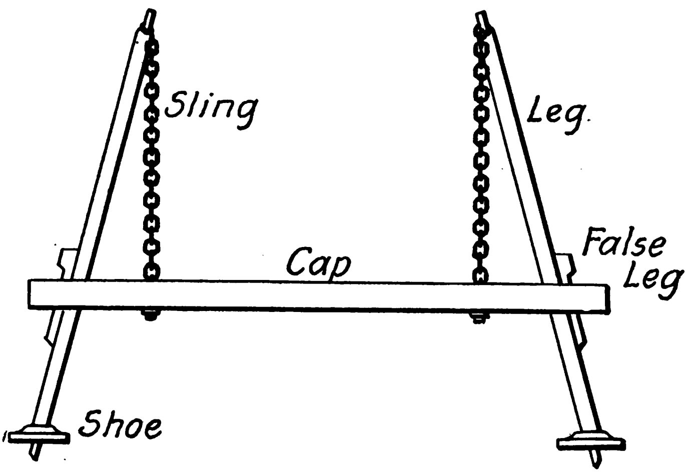


FIG. 59. BIRAGO TRESTLE

used. On dry ground or in very shallow water it may be assembled prone and raised into position by guy ropes. Over water it is assembled on a ponton raft and raised to the vertical, the cap resting upon two balks which project over the edge of the raft. The trestle balks are passed out from the shore and their double cleats hooked over the cap and the abutment sill on the bank. The shoes of the trestle are then forced down upon the bottom, the *false legs* or wedges driven, the chain slings adjusted, and the raft withdrawn. Chess are laid out to the trestle cap and the construction of the bridge proceeds as when building out from the shore. At the far end the trestle is placed in a similar manner, any surplus length of bridge being taken up by allowing a short bay between the last boat and the trestle or by setting the abutment sill back from the bank. The new *Rees Trestle* does away with the chain slings.

When there are not sufficient boats available to construct a bridge, some form of extemporized floating support must be constructed. Figs. 60 and 61 show, respectively, a barrel raft and a log raft. Before using such a raft, its buoyancy must be tested or computed, in order that it may not sink when the bridge is loaded.

In constructing the bridge, the boats are assembled, half upstream and half downstream of the abutment. The chess are piled on the right, the balks on the left, and the company is formed and divided into working parties as shown in Fig. 62. The first boat is brought from downstream to the bank (or alongside the trestle if used). The *balk carriers* bring out five balks, hook their cleats over the outer gunwale of the boat, where they are held in position by the *balk lashers* in the boat, and push it out until the cleats at the shore end of the balks engage the abutment sill (trestle cap or boat previously placed). The boat is then secured by cables to the bank. The *chess carriers* bring out the

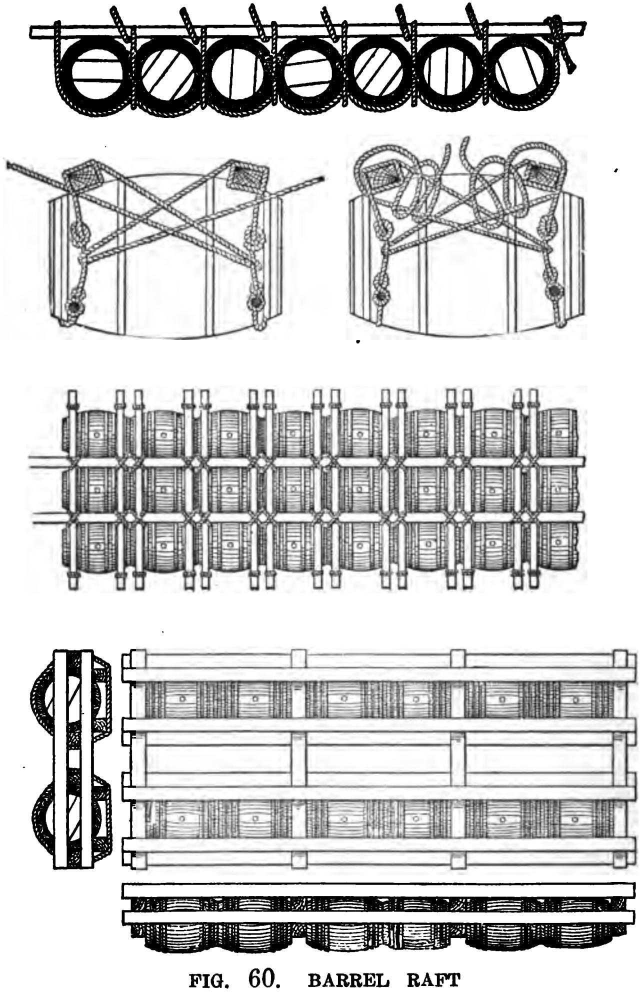


FIG. 60. BARREL RAFT

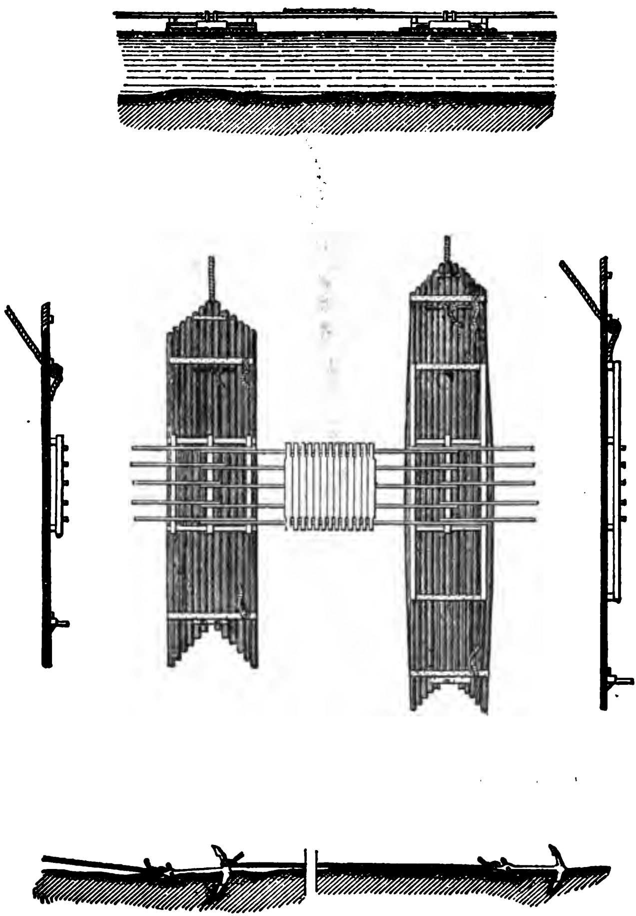


FIG. 61. LOG RAFT

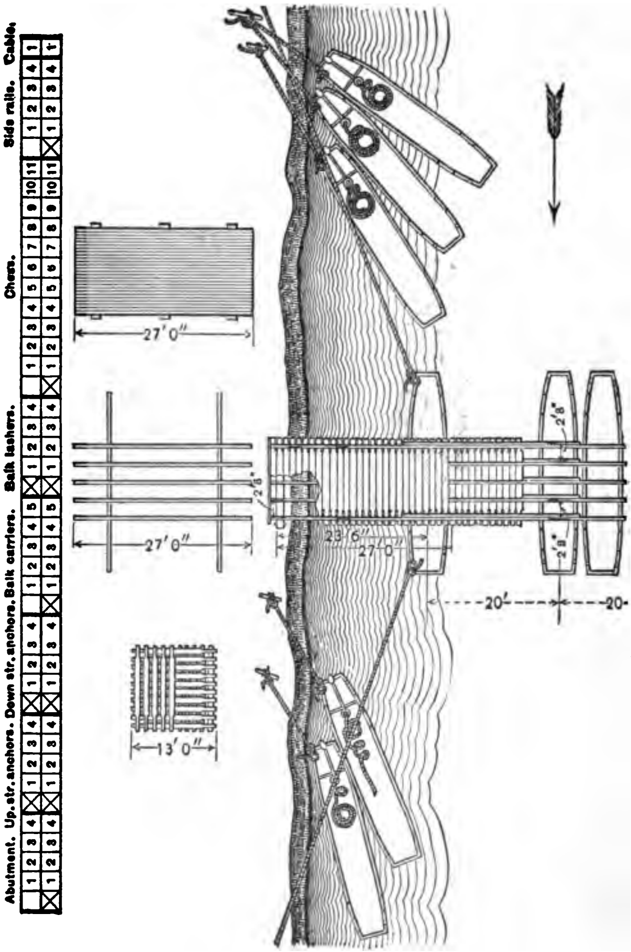


FIG. 62. FLOATING BRIDGE BY SUCCESSIVE BAYS

chess, which are laid across the balks out nearly to the first boat.

Boat No. 2, from upstream, drops its anchor opposite the position which will be occupied by *boat No.* 3 in the bridge, drops down alongside No. 1 and is pushed out as before. Both sets of balk are now lashed to the gunwales of No. 1 and chess laid out nearly to No. 2. The *side rail* detail place the side rails on the chess of the first bay, pass a lashing between the chess, around balk and side rail several times, insert a *rack-stick* in the loops and twist the lashing tight.

Boat No. 3, from downstream, drops anchor below its position on the bridge, comes alongside No. 2, takes the cable of the *upstream anchor* dropped by No. 2, is pushed out to position, and draws *both* anchor cables taut.

The construction of the bridge thus proceeds by the method of *successive bays,* and in the completed bridge alternate boats are anchored both up and down stream, the intermediate boats having no anchors. The balk, which are double over the boat and firmly lashed together and to each gunwale, preserve the requisite stiffness of the bridge.

To save time the method of construction *by parts* is sometimes adopted. (Fig. 63.) Different working parties construct a number of sections or *parts*, consisting ordinarily of three boats. These are floored over, excepting the outer boats of each section. Side rails are placed aboard but not lashed, and sufficient balk and chess are loaded to complete the flooring over the outer boats and over one interval between boats. One by one, these sections are brought to the bridge head, having first dropped their anchors or had them carried out by independent boats. The section is pushed out to the proper interval as in the case of a single boat, and the flooring completed with the extra chess. This method gains considerable time, and re-

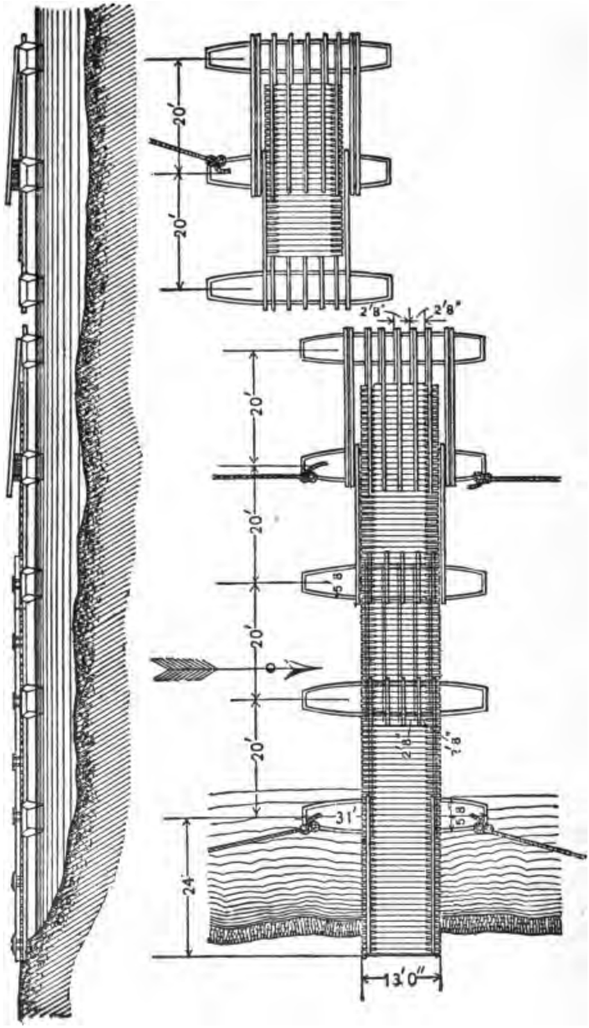


FIG. 63. FLOATING BRIDGE BY PARTS

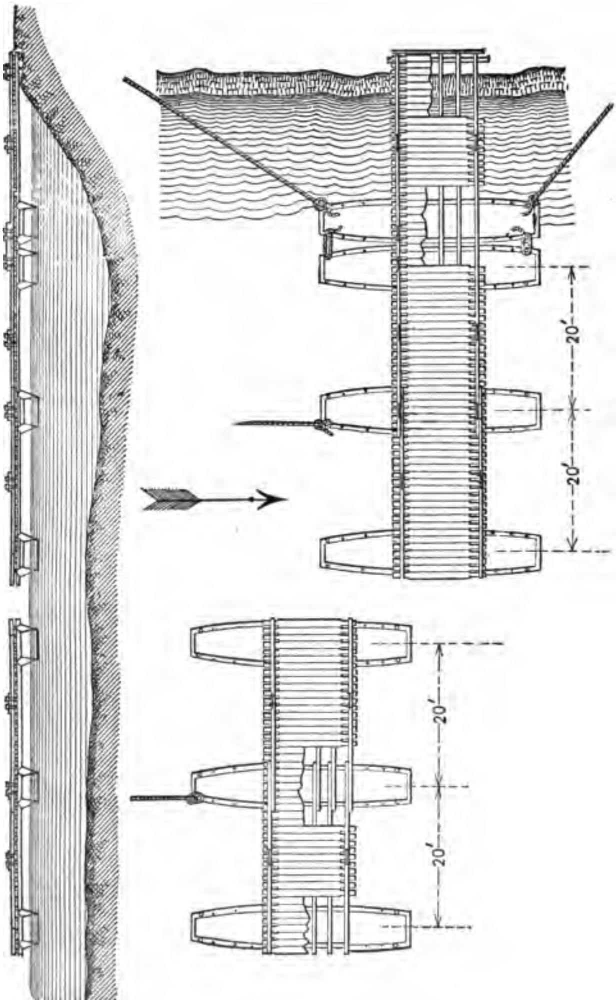


FIG. 64. FLOATING BRIDGE BY RAFTS

sults in a completed bridge identical with that constructed by successive bays.

The method by rafts is occasionally used, where boats are plentiful and extreme haste is necessary. (Fig. 64.) A *raft* is similar to the *part* described above, except that the chess are laid complete, from end to end, and the side rails placed and lashed. The bridge is constructed by lashing a number of rafts together, the end boats of each resting side by side. The resulting bridge is not satisfactory, as the piers are composed alternately of one and two boats. A load on the bridge, therefore, causes unequal settlement, and a heavy moving load subjects the material to a severe strain. The method is very little used except at some point in a bridge where it may be necessary to provide a draw. (Fig. 65.)

The method *by conversion,* which comprises construction parallel to the bank and swinging into position by the current, is seldom successful. It is a matter of record that Napoleon's engineers once used this method with great success, his troops crowding the bridge and springing ashore the moment it landed. (Battle of Wagram, 1809.) Hence the method still finds a place in the manuals and text books.

Fig. 66 shows the construction of a ponton bridge with the light equipage, and Fig. 67 the construction with the reserve equipage.

In crossing the bridge troops must break step, mounted men must dismount and lead their horses, and every care must be taken to prevent swaying or oscillating of the bridge. However taut the anchor cables may be drawn, the sinking of the boats under load will loosen them, and some oscillation will probably result. Those on the bridge must then be halted until it ceases, care being taken not to crowd together. In halting, heavy loads such as the wheels of gun carriages, should rest between boats.

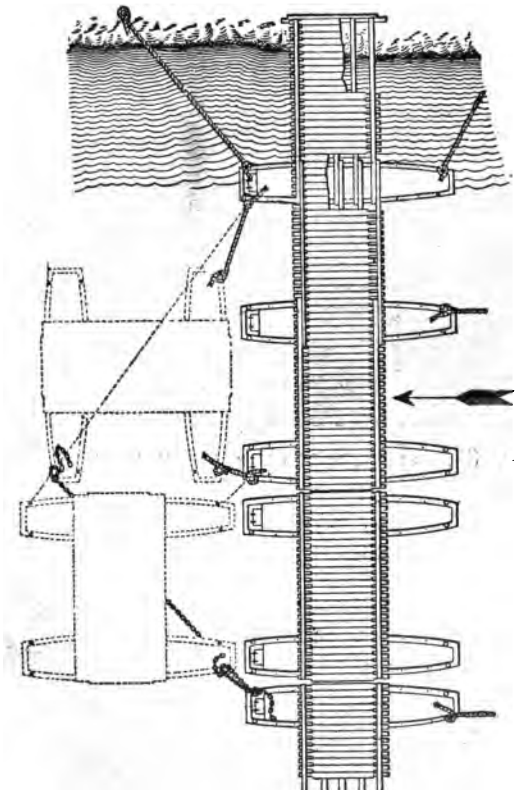


FIG. 65. DRAW IN PONTON BRIDGE

The floor system of a ponton bridge, with the balk overlapping the entire width of each boat, is too stiff to accommodate itself to the rise and fall of tidal waters without severe strain, so there must be some sort of hinge between the shore end, the elevation of

which is fixed, and the floating portion. This may be accomplished by placing a *saddle sill* over the axis of the first boat, so that the balk join at this sill and do

FIG. 66. CONSTRUCTION OF BRIDGE, LIGHT TRAIN

FIG. 67. CONSTRUCTION OF BRIDGE, RESERVE TRAIN

not have two points of support at the gunwales. Lacking such a sill, the shore balk may be ended at the near gunwale of the first boat, letting the balk of the second

bay extend entirely across the boat. The cap of the Birago Trestle cannot serve as a hinge, as it lies at a fixed elevation the same as the abutment sill.

To load pontons of the reserve train on their carriages, four methods are practiced.

1st. The rear wheels of the carriage are dismounted, and the boat pushed up the incline formed by the seven balk already in place on the wagon trucks. The wagon is then jacked up, and the wheels replaced.

2nd. The rear wheels are backed into a depression, usually dug out for the purpose, and the same proceedure followed.

3rd. Balks may be placed from the ground at the side of the wagon and the boat pushed up the incline thus formed, over the wheels and into place. This is the least to be recommended of any of the methods here described.

4th. The best method is to provide a barrel-shaped roller of sufficient strength (a strong barrel may be used if guided properly), place it in front of the boat, back the wagon up to within 10 or 12 feet, and push or pull the boat up over the roller and on the wagon. Such a roller may be made and carried along with the train, in one of the boats.

Where the ponton train is to be moved by rail, flat cars are used, and the number required is computed as follows: a 40-foot flat car will accommodate one ponton or trestle wagon and one chess, tool or forge wagon. A 34-foot car will carry one ponton or trestle wagon or two of the shorter wagons. A division of the reserve train, therefore, will require ten cars, of which six must be 40 feet in length, the others shorter. The distribution is as follows:

Four cars, 40-ft., one ponton wagon, one chess wagon on each.

One car, 40-ft., one ponton wagon, one tool wagon.

One car, 40-ft., one ponton wagon, one forge wagon.
Two cars, 34-ft., one ponton wagon each.
Two cars, 34-ft., one trestle wagon each.

If only 34-ft. cars are available, 13 are required, as below:

Ten cars, one ponton or trestle wagon each.
Two cars, two chess wagons each.
One car, one tool and one forge wagon.

To load the wagons, two strong skids are provided, each about 16 feet long, a foot wide, built with a side rail, and having hooks at the upper end to engage the iron sleeves on the car. These skids are placed at the end of the train, their centers blocked up, and the intervals between cars bridged. Or, an incline may be constructed of the ponton flooring. The wagons may be hauled up by about twenty-five men, walking along the cars, or a snatch-block may be rigged at the end of the first car and the pull made along the ground, by men or teams. The rope is attached to the running gear of the wagons, secured by a half-hitch near the end of the tongue for guidance, and a couple of men walk up the skids guiding the tongue. The wagons must be brought up in their proper order, a small wagon ahead of each ponton or trestle wagon on a 40-ft. car. After hauling up, the wagons are taken over by details of men and run along the train to their positions. Each wheel is blocked front and back, and additional blocks are placed outside each wheel, and connected by 2x4's passing between the spokes. The latter may be replaced by pieces of old brake hose, passing through the wheels and nailed to the car floor outside and inside each wheel. Tongues are removed and made fast under the wagons to which they belong.

In detraining, the wagons are best let down the skids by snubbing the rope on a post formed by driving a

piece of 4x4 timber into one of the iron sleeves at the front end of the car.

The entraining or detraining of a division of the ponton train should be accomplished in about 1½ hours, with ordinary troops, under competent supervision. If a long loading platform the height of the cars is available, the wagons may be loaded from the side, a number at once, and in much less time.

It is a popular opinion that the ponton bridge is like a picture puzzle, each part cut and fitted, and easily assembled. On the contrary, each bridge built is a separate problem, which calls for much hard labor and considerable ingenuity. Highly trained troops are required to operate the train and skilled mechanics to maintain it in condition for immediate use.

XIII.

TOPOGRAPHICAL SKETCHING.

HOW DIFFERING FROM SURVEYING METHODS.

Military sketching differs from the ordinary operations of surveying chiefly in the time required and the accuracy of the completed work. An error of 10 or 15 per cent. in the length of a road will not make so much difference to the commander if he can tell from the sketch *about* the time it will take to march the distance, whether the grades are practicable for his trains, and something of the topography on either side. Nor is the exact height of a hill of so much importance as its *shape,* whether there is dead space on its slopes, where it is too steep to assault, etc.

To the average engineer, the contours on a map are simply the statement of a mathematical problem; given: these contours, required: to compute excavation, locate gradients or balance cut and fill. To the military engineer, they mean *ground forms,* and his problems deal with dead space, visibility and command. It is often of vital importance to know whether a certain stretch of road is visible from an observation station, over the top of an intervening hill. Upon the correct solution of this problem depends the sending of troops by that route when their movements must be concealed from the enemy. The engineer, in making his map, works for accuracy, determining the location and elevation of ruling points and drawing the contours among them. The military sketcher works to *picturize information,* traversing the drainage lines as a skeleton and building around them by contours the ground forms which he sees.

Major Sherrill, in his "Military Topography," says: *No man can become an excellent sketcher until he involuntarily sees the map forms which would correspond to the ground observed; nor can he be a perfect map reader or scout until to see a map is at once to picture to himself intuitively the ground forms from which the map was made.*

Sketches must be made rapidly. The information must be turned in at the end of each day's march, and the sketcher must keep pace with an infantry column covering 2½ to 3 miles per hour. To sketch at this rate and deliver a contoured map with all required information necessitates careful training and considerable practice.

It is certain that nothing in the way of a topographical survey can be undertaken in the field during hostilities, even by reconnaissance methods. The information would not be available as soon as wanted, and the sketchers could not advance in front of their own forces to map the ground on account of interference by the enemy. For the proper conduct of operations on a large scale, therefore, dependence must be placed upon maps prepared before war is declared, and the great usefulness of the sketcher lies in the correction and amplification of existing maps, and in making road maps and position sketches covering small areas. The very fact that topographers must stay with their own troops, has the effect of limiting their usefulness to a great extent. They cannot map a position until it is occupied, therefore the information contained in their sketches can be of no use in effecting the occupation, and similarly as regards mapping a road in time to route the line of march. However, sketchers with reconnaissance patrols may be able to gain quite a distance to the front and turn in sketches which, while fragmentary, may, in conjunction with existing maps and fragments turned in by others, furnish very

useful information to the commander. No feature of the terrain that might be of military value, therefore, should be overlooked by the sketcher, whether that value be apparent to him or not. An engineer would not think of designing a foundation without the fullest information regarding the site, but the military commander can never be fully informed. He must consider all the information that he has, sift the true from the false as well as he is able, and base his action upon the partial knowledge that remains.

INSTRUMENTS USED.

The small plane table, about 14 inches square, with a compass needle set in one edge and mounted upon a light camera tripod, is the most useful instrument for mapping. The map is made complete as the survey progresses and nothing is left to fill in or to be completed later, as the sketch must be turned in at the end of each day, as soon as camp is reached, to begin the work of matching and reproduction.

The *sketching case,* Fig. 68, is a small plane table, intended to be used without a tripod. In use, it is strapped to the wrist or carried in the hand, and is for that reason particularly adapted to mounted sketching. A compass is mounted in the top edge of the board, and two rollers are provided to keep the strip of paper stretched. A map much longer than the board may be drawn by rolling up the completed sketch on one roller and feeding fresh paper from the other. The *alidade* is in the form of a jointed brass ruler, pivoted to the top edge. The board may be used to read vertical angles by loosening the pivot screw of the alidade, holding the board in a vertical plane and sighting across the screws at the top, allowing the alidade to swing freely. The angle is read on the scale at the base of the board. The cover of the compass can be revolved by a stud set at one side, and two

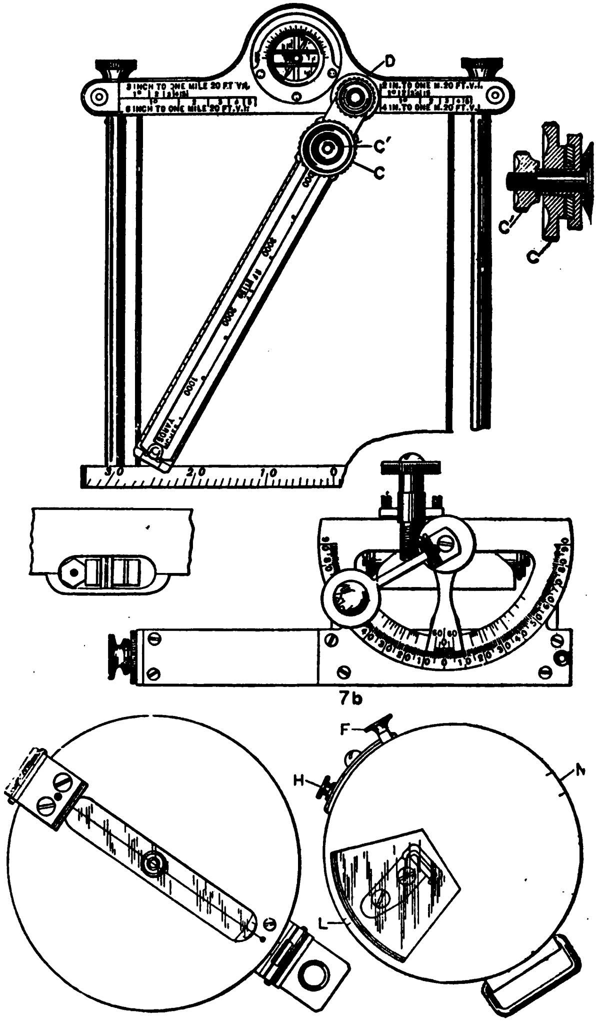


FIG. 68. RECONNAISSANCE INSTRUMENTS

parallel wires are mounted on the cover glass, revolving with it. In commencing a sketch, the board is pointed in the desired direction, the needle allowed to come to rest, and the wires revolved to a position parallel to the needle. They must not be again moved during the making of the sketch. In taking each sight, the board must be oriented by turning it until the needle comes to rest between and parallel to the two wires, or swings equally on each side of their axis. In sighting, the board is not raised to the height of the eye and the alidade aimed at the point, but is held in front of the body and the ruler pointed by looking alternately at the point and the ruler, as in plumbing down from a high point by eye. In Fig. 68 the detail at the right is of the clamp screw on the alidade. Loosening the small top screw C^1 permits revolving the lower link about the pivot, while the large screw C controls the motion of the pivot along the slotted upper link. The lower detail shows the end of the pencil slot under the board.

Below the sketching case, Fig. 68, is shown the *Abney Clinometer,* used to read vertical angles. The line of sight through the tube is divided, half of the object end being open, with a horizontal wire across its center, the other half is closed by a diagonal mirror, permitting a view of the bubble which is mounted above the tube. The bubble and the target can thus be seen at the same time, and if the bubble is brought to the center, the graduated arc will give the angle of elevation or depression. The clinometer may be used as a hand level by clamping the circle at zero and keeping the bubble in the center of its tube while sighting.

The *service clinometer* (lower right-hand corner of Fig. 68), is used for the same purpose, but depends upon a weighted pendulum in place of a bubble. The line of sight is through the eye hole, L and the orifice N. A small mirror is mounted at the center of the

instrument and reflects to the eye a circular scale mounted on the pendulum and illuminated by the glass window shown. The scale is graduated in degrees and is seen at the same time as the target, so that the vertical angle is read direct. When the scale reads zero the line of sight is level and the instrument may be used as a hand level. The pendulum is released to revolve by pressing the button F which, in turn, may be locked by pushing forward the slide H. This instrument is quicker of operation, but not so accurate as the Abney type. It is sufficiently accurate, however, to meet all requirements of military sketching.

The *prismatic compass* (lower left-hand corner of Fig. 68) is used to read bearing or azimuths, the card being usually graduated to read clockwise 360 degrees from the north. The cover lifts to a vertical position and forms the front sight. The prism turns up over the edge and forms the rear sight, allowing at the same time a view of the edge of the compass card, rotating beneath it. A push button under the front hinge stops the card at will, so by checking it in the middle of its swing it may be more quickly brought to rest.

The *aneroid barometer* is used to find differences of elevation. It gives best results when the start and end of the survey are at points of known elevation, allowing interpolation for intermediate points, or when used in conjunction with a standard barometer read regularly at one station to register atmospheric changes.

METHODS.

The plane Table is set up at the starting point, oriented by compass, and the position of the first station is assumed on the board, having due regard for the direction in which the sketch will proceed and the area to be covered. With the edge of the alidade passing through this initial point, a pointing is made towards the next station and a line drawn along the edge. Sim-

ilar sights are taken and lines drawn in the direction of various features which it is desired to locate upon the map. The distance to these points may be measured by pacing or may be estimated, or a second sight taken towards them from another station, the intersection of the two giving the location. Angles of elevation or depression may be read by the clinometer, as an aid to contouring. When ready to move, the board is taken up and the sketcher walks towards the second station, counting his paces or keeping a record of them with a *pace tally,* which is a watch-shaped counting device held in the hand and actuated by pressing the stem at each stride or step. As he proceeds he keeps mental or written notes that at 90 paces a house was passed, 30 paces to the right of the road, at 145 paces a stream was crossed on a wooden truss, 40 ft. long x 16 ft. wide x 12 ft. high, at 181 paces a railroad was crossed at grade; making an angle of 60 degrees with the road, etc. Upon arriving at the next station the board is set up, and oriented by compass or by backsight. Using a scale of his own paces, he first plots the distance between the stations along the line already drawn, thus locating Station 2. The notes taken along the way are then plotted, then a sight taken to the next station, and to various side points. The survey proceeds by repeating these operations.

Mapping is done with a soft pencil upon vellum tracing paper, or, in wet weather, upon sheets of celluloid, roughened on one side to take pencil lines. Sketches upon this material are not damaged by rain.

The sketching case is used in exactly the same manner as the sketching board, except that it cannot be oriented by backsights unless placed in a steady position upon a fence post, the ground, a stone, etc. Maps drawn with the sketching case are not so accurate as those made with the sketching board, as the pointings or orientations cannot be made so closely.

The *Prismatic Compass* is useful in running traverses for control, or to obtain bearings to important objects. If used for filling in, it either takes two men, one to read bearings and the other to plot and sketch, or one man must do both and take twice as long, or the plotting must wait until the reconnaissance is completed and must be done out of sight of the ground to be sketched, which means that more elaborate notes must be taken to aid his memory.

The Engineer Note Book, Figs. 69 and 70, shows a method once much used. The two plates are almost self-explanatory. The record is started at the bottom on the left-hand page, the record of distances and the alignment is kept in the center column, also azimuths of side shots. In the columns on either side of the center are placed the offset distances, and in the outer columns the descriptions. Azimuths are read by the prismatic compass. On the right-hand page, Fig. 70, is shown the plot of the notes in Fig. 69.

Contouring.

For assistance in contouring, a device known as a scale of *map distances* is used. On a map of a given scale contours of, say 10 feet interval, are spaced a certain distance apart on a 1 degree slope. On a map of half the scale this distance is reduced one-half, but on a map of *half* the scale and *twice* the contour interval, the contours will be spaced the same distance apart for a 1 degree slope as in the first map. Similarly for slopes of different degrees.

In the U. S. Army, three principal scales are used for sketching, as follows.

Nature of sketch.	Scale.	Representative fraction.	Contour interval.
Road sketch........	3 in. = 1 mile	1 : 21 120	20 Ft.
Position sketch	6 in. = 1 mile	1 : 10 560	10 Ft.
Fortification sketch.	12 in. = 1 mile	1 : 5 280	5 Ft.

Remarks Left.	Offsets Left.	Courses & Distances	Offsets Right.	Remarks Right.
Crossed wagon road		1230	230	Road running N.& S.
running E.& W.		4° R		through Alpine
Crossed dry Cr.		880		village.
Cr.	12	100	230	Farm H.
Cult.		18°00'		
		⊙5		
		3256		
		$7^h 41^m$		
R.R.Br.	100	4000		
Cr.	25	3080		Crossed dry Cr.
		2765		Crossed wagon road
Cr.	2	2465		Crossed dry Cr.
R. R. Br.	100	2300		
R. R Br.	250	1760		
		1660	200	Farm H.
		1650		Crossed Wagon road
				running E. & W.
Creek 30 wide	440	620		
Woods along Cr.				
		34°00'		
Rolling Prairie		⊙4		Pasture
Pasture		1230		
		$7^h 4^m$		
Farm H.	110	800		
Farm H.	150	600		
		450		Crossed wagon road
		230	160	Farm H.
		1.5° R		
		303°00'		
Corn & Wheat		⊙3		Corn & Wheat
		1530		
		$6^h 50^m$		
		1230		Crossed Cr. 15 wide.
Creek, dry run	130	880	175	Farm H.
		3° R		
		343°00'		
		⊙2	50	Farm H.
Left wagon road		230		Cult.
Cult.		$6^h 33^m$		
Farm H.	25	200		Level Country
		100	10	Farm H.
Left Mokena $6^h 30^m$ AM.		0°00'		Following wagon road.

Sept. 4th. 1900. $6^h 30^m$

⊙1 All distances in Yds.

Beginning

FIG. 69. ENGINEER NOTE BOOK

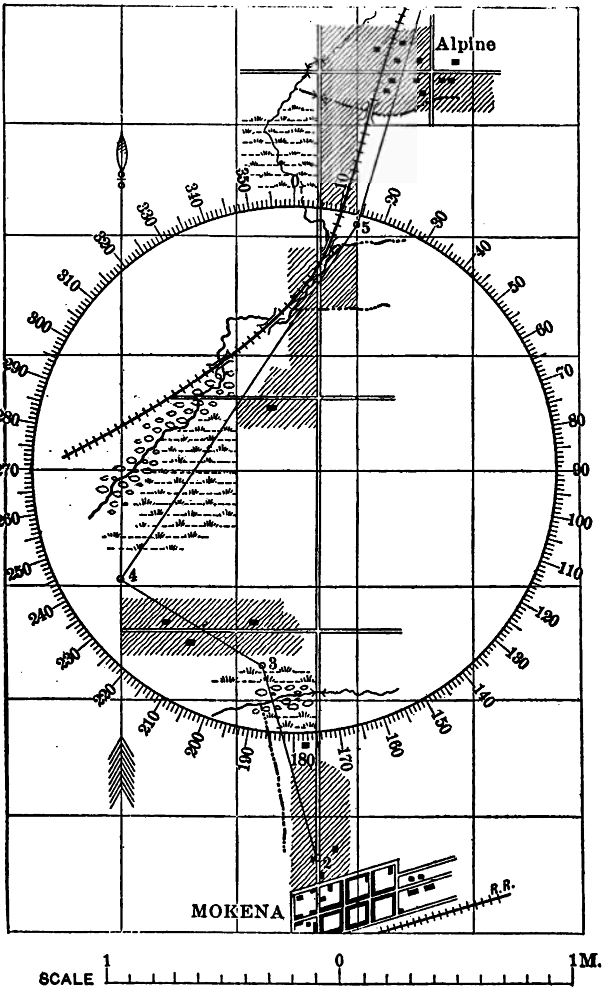


FIG. 70. ENGINEER NOTE BOOK

It will be noted in this table that as the scale is increased the contour interval is reduced in like ratio, so the same map distances will apply to maps of all three scales. (Fig. 71.) The use of this scale is simple

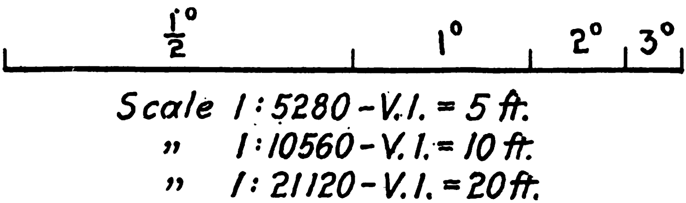


FIG. 71. SCALE OF MAP DISTANCES

and will often obviate the necessity of referring to a table to find differences of elevation.

A hill to the side of the road is located by intersection and plotted. The slope from the station to its summit is measured by a clinometer or slope board and found to be 2 degrees. It is then determined by trial how many times the map distance for 2 degrees will fit into the plotted distance to the hill. This figure gives the number of contours which must be drawn between the two points on the map, and, multiplied by the contour interval, gives the difference of elevation. If the slope between the points is uniform, the contours are spaced equally, according to the map distance. If flat for half the distance, no contours are drawn in this half and the total number are crowded into the other half. If the slope is concave the contours will show it by being drawn closer together near the summit and *vice-versa.*

Figs. 72 and 73 show the ordinary topographical symbols used in military mapping. When pressed for time, the sketcher will not fill in a space with symbols, but will draw a wavy line around it and write "Woods," "Cult.," etc. inside.

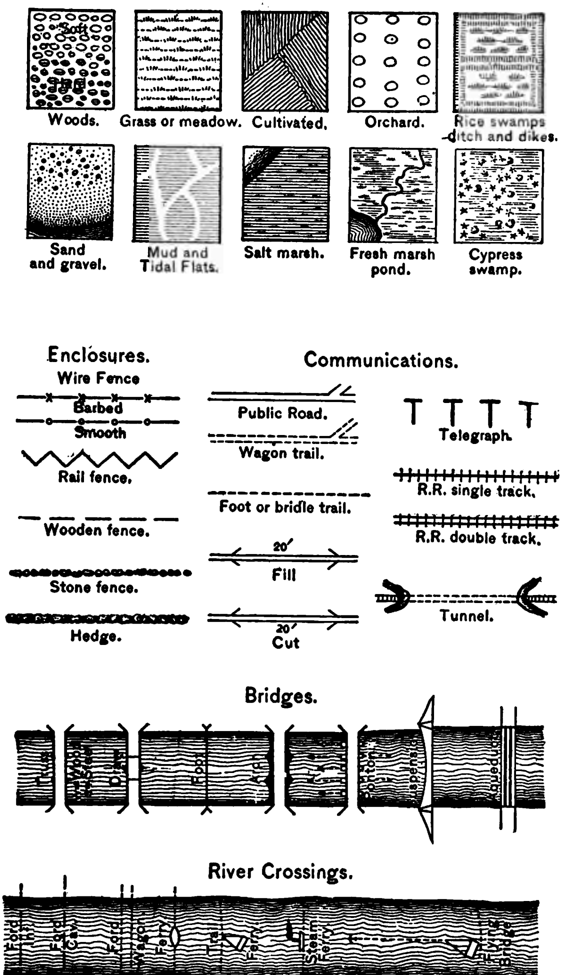


FIG. 72. TOPOGRAPHICAL SYMBOLS

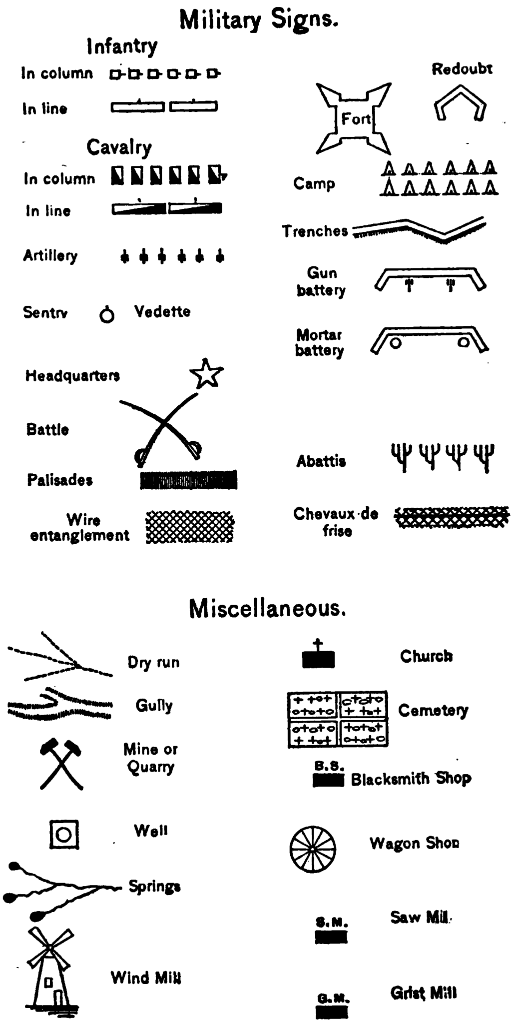


FIG. 73. TOPOGRAPHICAL SYMBOLS

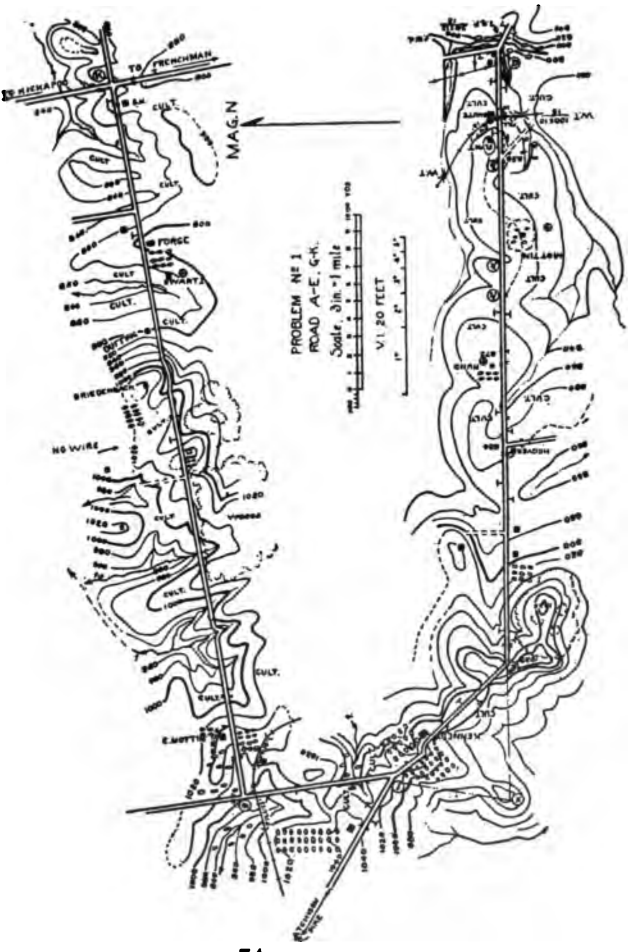


FIG. 74. ROAD SKETCH

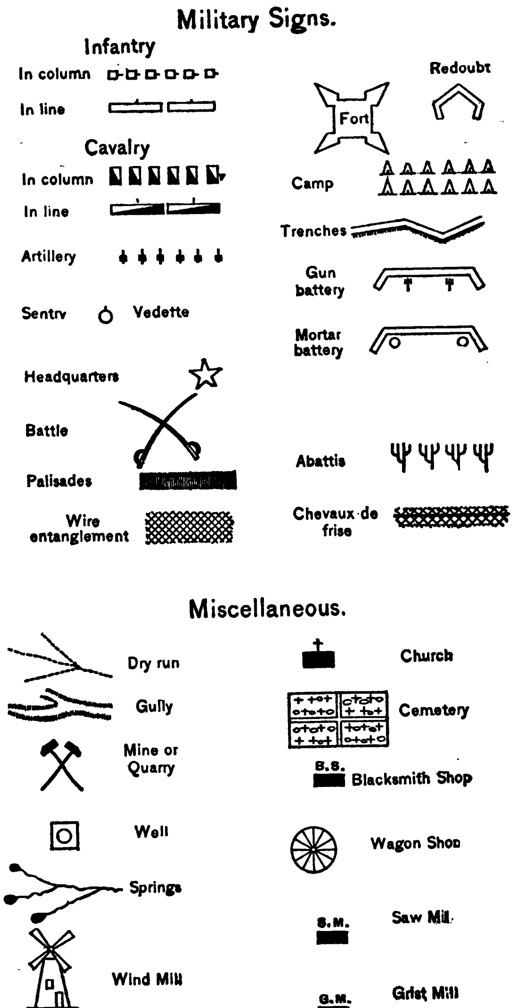


FIG. 73. TOPOGRAPHICAL SYMBOLS

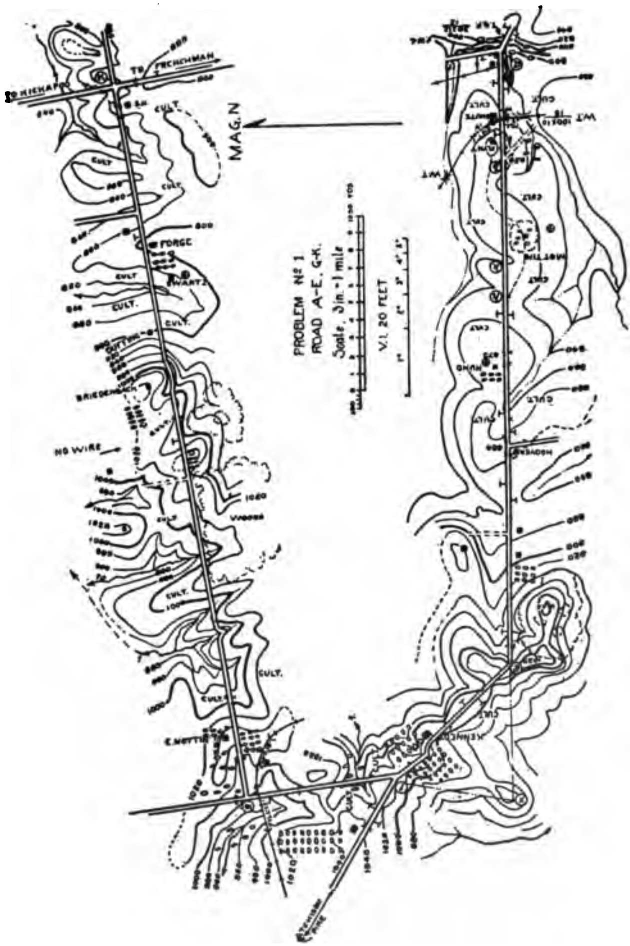


FIG. 74. ROAD SKETCH

Fig. 74 shows a road sketch reproduced from Sherrill's "Military Topography" which will give a fair idea of the character of work done.

VISIBILITY.

One of the problems which confront the military man in reading maps is the determination of the visibility of one point from another. This is of importance in laying out a field of fire to avoid dead space, and in movements of troops which must be concealed from the enemy. The problem can sometimes be solved by inspection, as when the difference of elevation of the points in question is large and the intervening point is not much higher than the lower of the two, or when the height of the intermediate point lies about halfway between the two end points and it is situated nearer the high end. On a concave slope points will be visible from all other points, and vice versa.

By scaling the distances between points and taking their differences of elevation as shown by the contours, the slopes may be computed and compared to determine visibility, or, as a final resort, a complete profile may be constructed from the map and a straight-edge applied to see whether the line of sight will clear the obstacle. The labor of applying this method to a map to outline a complete zone of dead ground from a certain position would be considerable, however, and it is usually only the doubtful points which are thus treated. In all visibility problems the presence of trees and other vegetation must be considered and allowed for. If the location of a trench is in question the visibility must be determined upon the actual ground.

MAP REPRODUCTION.

When the sketches are turned in at night, they are matched, closures forced by cutting and pasting, and

the whole combined sketch is reproduced for sending out with the orders for the following day. In operations involving large bodies of troops, maps are needed in considerable numbers, and it becomes necessary to employ a method of reproduction which is rapid and capable of producing work in quantity.

Blue-printing is about the simplest process, but is very slow, especially when done at night under such artificial light as is available in the field, so a lithographic method has been developed for field use, differing from true lithography in that a zinc plate is used instead of a stone. The process is called *zincography* and the machine with which the work is done is called the *zincograph.*

The equipment consists of a working table, a press resembling a large clothes wringer, an ink roller, the various chemicals and solutions used, and the container, which is a large three-storied chest, in the upper compartment of which is stored the press, and in the lower two the solutions and supplies. There are two processes by which drawings may be reproduced, one of which is dependent upon sunlight or some strong artificial light, the other of which requires no such light but necessitates copying the entire drawing to be reproduced.

In the latter, or transfer process, the zinc plate is of a No. 19 B. & S. gage, and has been so treated as to give the surface a slight grain. This may be accomplished by immersing the polished plate in a solution consisting of one gallon of water, two oz. nitric acid (commercial) and one oz. of alum. The result is a dull satin gloss finish. The drawing to be reproduced is traced on a thin coated india paper known as autographic transfer paper, with transfer ink, such as is used in the hectograph process. Care must be taken not to touch the surface of the paper with the bare hand, as the natural grease of the skin will cause all finger prints to be reproduced in the finished print.

The tracing is then placed between two moistened sheets of blotting paper until it has become thoroughly dampened. It is now ready to transfer to the plate.

The dampened drawing is placed face down on the grained surface of the zinc plate, which is then run through the press several times, moistening the drawing at intervals with a wet sponge. The paper can now be peeled off, leaving the ink lines on the plate. The plate is dried by fanning and then covered with a thin coating of gum solution, which is made by boiling one pound of dextrine in a pint of water. The plate is then given a coat of ink, applied with a piece of cheese-cloth, and sponged with water. The latter operation removes the ink from that portion of the plate not occupied by the lines of the drawing. If these lines do not now show up well, the operation is repeated until all lines are well defined. Any line that has not transferred to the plate may be drawn upon it with a pen or a fine brush. While the plate is still damp from the last sponging, it is worked over with the ink roller, the ink from which adheres to the lines, but may be easily wiped off from the damp portions of the plate. After removing the surplus ink, the plate is dusted with powdered resin and again sponged with water.

In order to print from the smooth plate, it must be treated so the ink from the roller will adhere to the lines and not to the remainder of the plate. Ink will take on a greasy surface but not upon one which is damp, and in order to insure a moist surface on the plate, it is etched with nitric acid and the etched portion filled with gum, to which the ink will not adhere. The etching solution consists of 4 oz. of nitric acid in two gallons of water. The powdered resin is only a partial protection for the ink lines, therefore the plate must not be left in the etching solution more than about one minute. Upon removal from the acid, the plate is sponged with water, dried, and the gum solu-

tion poured over it, the surplus being allowed to run off.

Printing is now done by moistening the plate with damp cheese cloth, inking it with the roller, covering it with the paper and running it through the press. The first print can be obtained in from 15 to 30 minutes after the tracing is made, depending upon the amount of building-up required by the ink lines. For rapid printing two men are required. No. 1 dampens the plate, No. 2 inks it with a hard roller from an ink slab, No. 1 inserts it in the press and No. 2 turns the crank of the press. Copies can be printed at the rate of six per minute.

The second process depends upon contact printing, and requires a strong light, preferably the sun. As most of this work in the field must be done at night, however, this process will not be much used. The plate is sensitized with a solution consisting of 120 grains of dry albumen or the white of one egg, 15 grains of ammonium dichromate and 7 oz. of water. The plate must be thoroughly cleaned before applying the sensitizing solution, and after the latter has dried the plate must not be exposed to the light. A maduro negative must first be made of the map to be reproduced, which may be printed from the patched-up field sketches. The plate is then placed in a printing frame with the negative, which latter must face *away* from the plate, to insure lettering, etc., reading correctly on the finished print. The exposure depends upon the intensity of the light, and also upon the transparency of the negative, varying from 10 to 15 minutes. The progress of the printing may be observed by opening the frame at intervals, care being taken not to alter the relative positions of the plate and the negative.

Immediately upon removal from the printing frame, the whole plate is covered with ink from the roller, to prevent further action by light. It is then developed

in water, as in the ordinary blue print process. While still immersed in the water the ink may be wiped off with cheese-cloth. When fully developed the plate is removed from the water and dried by fanning, then dusted with powdered resin, the surplus of which is wiped off. The process of etching and printing then proceeds as in the first method.

The plate may be prepared for further use by removing the ink with turpentine and washing thoroughly with lye. Regraining is necessary only after the plate has been used a number of times.

The first method is better adapted to field use, but the second will do finer work. It is even possible to reproduce photographs by printing from a film or negative on the sensitized plate.

The zincograph is a part of the equipment carried by the engineer battalion in the field. Each company is equipped with a clay *hectograph,* from which about 50 copies can be made from one impression.

The sketch is copied in transfer ink, laid face down upon the level clay surface and allowed to remain for one or two minutes. Printing is done by laying blank sheets of paper on the clay, smoothing them out and taking them off immediately. Sketches may be reproduced by this method in three colors.

LANDSCAPE SKETCHING.

Sometimes information may be better conveyed by a landscape sketch than by a map, particularly as to relief. It may take a great deal of mapping to make clear what can often be shown by a few strokes of the pencil. The sketch also has the advantage of showing in detail just what points it is desired to bring out, leaving non-essentials out entirely or subordinating them to the important points. A photograph cannot do this, as it must show all that is before

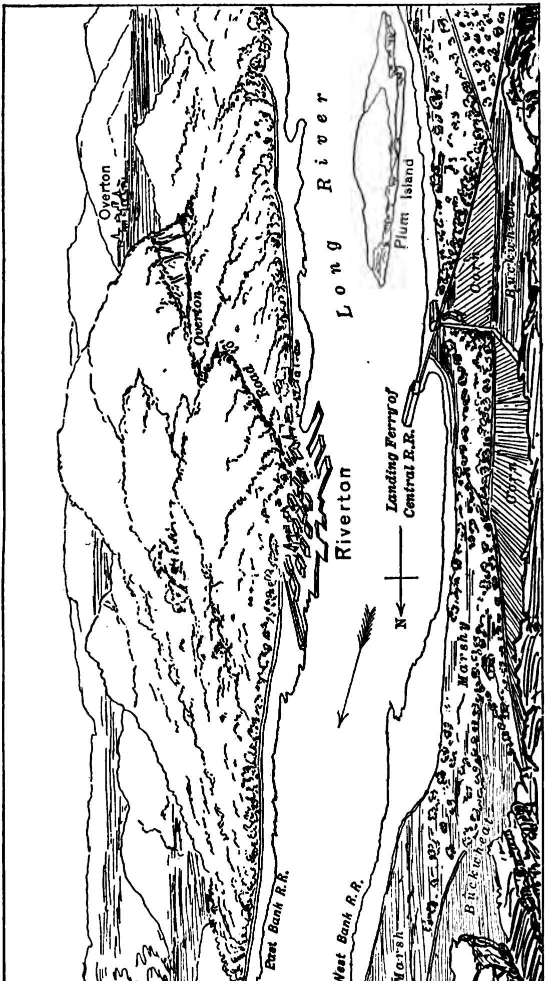


FIG. 75. LANDSCAPE SKETCH

the camera, and in its very accuracy and fidelity to actual conditions, the military information which it is desired to emphasize may be entirely lost.

Fig. 75 is an excellent example of a sketch of this character, reproduced from the Engineer Field Manual. This shows features which would have necessitated actually traversing the terrain and the expenditure of much time to show on a map, and even then the information would not stand out at a glance as it does in the sketch.

In making a sketch of this character the pad is held out in front of the eye until it covers the area intended to be drawn. Then, lowering it slightly, the position of the various hill tops, road crossings, etc., which it is desired to show are marked off on the upper edge of the pad. Similarly, the vertical distances are marked off on one side of the pad. The co-ordinates of all the important points are thus determined and the completion of the sketch consists of connecting these points and filling in such detail as may be required. Heavy lines are used for outlines of objects in the foreground, medium for those at mid-distance and light for distant objects.

An excellent treatise upon the subject is M. Lefebvre's "Military Landscape Sketching," translated by Capt. Judson, Corps of Engineers, U. S. Army, and published as "Occasional Papers No. 3" by the Engineer School, Washington Barracks, Washington, D. C.

CHAPTER XIV.

NEEDS OF THE ENGINEERS IN WAR.

The foregoing chapters have presented a very incomplete outline of some of the engineering duties and a few of the military duties which will devolve upon the engineer company officer in time of war. These subjects are large and have barely been touched upon in this discussion, and there are others which have not even been mentioned. Nothing has been said upon the subject of infantry tactics, which will probably occupy as much of an officer's time as the technical work. Similarly, no mention has been made of the services of security and information, with their subdivisions of outposts, advance and rear guards, patrolling and minor tactics. Camp sanitation, though often introducing problems in disposal of waste and protection of food and water supply which would tax the ingenuity of the average municipal sanitary engineer, has been omitted, and also the subject of military law and government. Coming down to the field of engineering itself, there will be found no mention of roads and railways, though not every engineer knows how to lay a corduroy road correctly or that the gage of a military railway is made 4′-9″, to allow for irregularities of track laying. All these things are beyond the scope of a work of this character, the main purpose of which is to point out the way for the engineer, not to instruct him. It is hoped, therefore, that the material presented will give an idea of the magnitude of the problems which will confront engineers in war and point out the necessity of individual preparation.

Need of Officers and Non-commissioned Officers. The army which would be required by the United States as

a defense against invasion is placed by the most conservative estimates at one million men. In the Civil War we called two million and a half men to the colors, and that was before the days of large armies. With an army of one million we should need 60,000 engineers, of whom 2,000 would be officers and 11,500 non-commissioned officers. The latter are as important to the army as the officers, and particularly so in the engineers. No man should hold a corporal's warrant who is not fully capable of performing the duties of a foreman of construction on civil works, and the grade of sergeant requires a man competent to fill the position of overseer or superintendent on a construction job. Every engineer must not think that his training would in itself entitle him to a commission. Many who entertain this view might find it difficult to hold down a sergeant's job. It is, however, within the reach of every engineer to qualify himself for a commission, and those who do not are contributing to the shortage of officers which will occur upon the outbreak of war, as well as depriving themselves of a military position on a par with their education and social connections.

First-class privates of engineers are skilled workmen: carpenters, blacksmiths, machinists, riggers, electricians, and mechanics of all kinds. Technical men can even find a place in the ranks as sketchers, etc. Second-class privates are of the class of outdoor workmen met at civil works. Lumbermen, miners, boatmen, teamsters, chauffers and laborers are fair examples of men useful in the Engineers. The lines between the two grades of privates are not closely drawn, length of service, special experience or adaptability often advancing a man from one to the other.

It is probable that many engineers must serve in the ranks as privates and non-commissioned officers, and there is no disgrace in such service. The best citizens of Europe are doing this now, and there is no

reason why Americans should be exempt when the time comes. Prof. Rawson, in his "Naval Battles of the World," says of the officers and men aboard the warships, "All in the service are equally servants of the state, and each position is an honorable one, the grades of honor ascending with the degree of responsibility required." A company commander respects and relies upon an efficient and dependable non-commissioned officer as much or more than upon his subaltern officers. Many of the sergeants of the U. S. Engineers have a reputation throughout the Army for their engineering skill, and their practical knowledge of the details of the engineer soldier's work is probably in excess of that of many officers. It means something to be a sergeant in the Engineers.

But all cannot be privates, corporals or sergeants. There must be about 2,000 officers, and the engineers of the country must furnish them. There are about 248 in the Corps of Engineers of the Regular Army, and less than one hundred in the National Guard, probably less than 300 in all who could be relied upon for active field duty. The field officers can be supplied from the Regular Army, but about 480 captains, 960 first lieutenants and 360 second lieutenants must be found somewhere, and from where are they to come? From civil life direct? Does any engineer reader who has had no military training believe that he can successfully lead engineer troops in the field? Men are quick to detect uncertainty or hesitation in an officer, as a horse recognizes lack of confidence on the part of his rider, and to lose faith in their leader is the first step towards the complete disorganization of troops.

General Morrison, author of "Minor Tactics" and "Infantry Training," says:

"The responsibility resting upon an officer in time of war is great. His mistakes are paid for in blood. To seek a command in war beyond his capabilities is no less

criminal than for a man with no knowledge of a locomotive or railroading to attempt running the engine of a crowded express train on a busy line."

National Guardsmen as Officers of Volunteers. Since engineers have taken up seriously the question of military preparedness, the writer has been approached by a number of technical men seeking information regarding service in the Engineers of the National Guard. Some of these desire to enter as officers, which is of course not possible except to those who have had definite experience in military engineering; most of them ask, "How long will it take to become an officer?" To this no definite answer can be given, as the time required depends upon several factors: the man's ability, the existing vacancies, and the competition developed. In the writer's company, during one year, three technical men, with no previous military experience, were commissioned second lieutenants after one year's service. This required extensive preparation on their part, and more time was spent in study than at regular drills, but any engineer who is ambitious enough to work, and has confidence in his ability to win out in competition with other men, may do the same.

It is realized, however, that with a large technical personnel in the Engineers, well qualified men might fail to obtain commissions through lack of vacancies, and thus become somewhat discouraged after a length of service which, in their opinion, should entitle them to advancement. The answer is simple. If you cannot hold commissioned rank in the National Guard, you can insure that in event of war *you will immediately receive the rank for which you are qualified.* Under the provisions of an Act of Congress of Jan. 21, 1903, any person in the Army or the National Guard, or with previous experience in either, may apply to the Division of Militia Affairs of the General Staff for an examination in any grade for which he thinks himself quali-

fied. Upon passing he receives a certificate entitling him to a commission in any volunteer force, outside the Organized Militia, which may hereafter be raised.

The National Guard can thus perform a great service in fitting men for commissions in the Volunteers. A number of Militia organizations, as for instance the 7th N. Y. Infantry, have always furnished large numbers of officers of Volunteers in past wars, and there is no reason why the engineers should not do the same for their own branch of the service. This will require additional work for the officers, in holding schools for the men and instructing them in subjects in advance of their duties in the ranks, and will necessitate extra attendances for the men, but such work would be entirely voluntary, and the man can decide for himself whether he wishes to spend the time to acquire an officer's training.

The dream of some National Guard officers is an organization at war strength, ready to take the field intact, and were the Organized Militia sufficient in numbers for all demands that might be made, such a situation would indeed be ideal. But under the present system we must be reconciled to losing our best trained men to the Volunteers, where they will become officers and non-commissioned officers. It would be manifestly unfair, both to these men and to the volunteer organizations, to retain them in the militia for the sole benefit of the latter. Probably the best trained infantry troops that could be put into the field would be the battalion of cadets at West Point, but their use as such would be very poor management, to let many organizations suffer from a lack of competent officers, in order that one small part of the army might be highly efficient.

CHAPTER XV.

CONCLUSION.

In the course of the preceding discussion the following points have been presented:

First, that the work of the military engineer is of a highly technical character, not to be successfully prosecuted without previous training and experience.

Second, that an officer must be first a soldier and after that an engineer. With the highest of professional attainments the engineer must fail as an officer if he cannot administer the affairs of his command and keep his men in condition under all circumstances to be of effective use when required.

Third, that were qualified men ever so numerous in this country, the work of enlisting and organizing them would be absolutely prohibitive of their early use in campaigns. *Troops available for prompt use in war must be organized before that war begins.*

Fourth, that any action of Congress looking towards a better military preparedness is uncertain, and will require many months to perfect, and whatever plan is finally adopted, it must utilize to a large extent the personnel of the National Guard *because of the military training which they already have.* Any man, therefore, who strives to obtain a part of this training in the meantime can feel that he is not wasting his time, and that what he learns will fit in with the new plan.

The National Guard is not urged as a cure-all for our military disorders. Its faults are recognized by its own members as well as by Federal officers, and most of these are of a sort that cannot be eradicated by any effort upon their part. The most severe critics of the Guard admit that it is composed, for the greater part,

of hard-working officers and men, who have very little to attract or hold them in the service. There are many cases, also, of poorly trained units, with inefficient officers and indifferent men. These faults could be remedied to a large extent if the proper sort of men would take up the work and try conscientiously to improve conditions. The fact that a city has a rotten municipal government is not so much the fault of the politicians in control as of those citizens who are qualified for public office, but are not willing to accept the responsibilities and inconvenience attached to it, or who will not take the trouble to cast their vote against it.

In the Engineers, particularly, is this lack of support apparent. In New York there has been much complaint by State and Federal authorities that the Engineers were not up to the professional standard of the other troops. The reason is simple. There are not enough technical men in the ranks. In teaching topographical sketching to a clerk, salesman or office man, he must first be taught the meaning of azimuth, declination, and how to construct a scale of his own paces. An engineer can begin to learn where he leaves off. The officers are tied down to elementary instruction and have no opportunity to rise above it. To develope a good sketcher from a bookkeeper is possible, but to make him proficient as an instructor, to take the elementary work off the officers' hands, is seldom accomplished.

The National Guard can be greatly improved, by changing the system under which it exists and which is responsible for most of its troubles, but more particularly by the co-operation of the right kind of men, and by co-operation is meant active support, including service in the ranks. The proposed legislation may contribute largely to its betterment, or may produce a better system altogether, but in the meantime the National Guard is the *best* we have and *all* we have, and to slight

the Guard because of its admitted imperfections is to neglect the best interests of the country.

The writer does not advocate a general enlistment of all engineers in the Organized Militia. Much can be done outside its ranks. Employers can encourage enlistment on the part of young men in their employ by making this step easy for them. Many a young man would be in the Guard today but for the fear that it would interfere with his professional advancement. Many men cannot arrange their time so as to perform military duty. Some of these can attend the summer training camps, some can accomplish much by study in preparing themselves for work in the rear of the field forces. But for the man who has the education, the physique and the energy to become an officer of engineers, there can be no more patriotic act at the present time than enlistment in the National Guard.

No amount of talk for preparedness or resolutions favoring it can be relied upon to add to our forces one capable soldier, nor to reduce in the slightest degree the confusion which would rule the country when war became imminent. Any plan for preparedness must fail which does not in the end rest upon *individual* effort and *personal* service.

THE END.

APPENDIX I.

The following is a list of reading upon military subjects recommended by the Chief of Engineers, U. S. Army, for the use of civilian engineers:

WAR DEPARTMENT

OFFICE OF THE CHIEF OF ENGINEERS

Washington, November 27, 1915

Military Reading for Civilian Engineers.

By authority of the Secretary of War, and in response to frequent requests, the following suggested list of reading is published for the information of civilian engineers desiring to inform themselves on military subjects.

These references have been selected, first, with a view to giving the engineers unfamiliar with the art of war, a general survey of that subject—an understanding of which is the first essential to insure successful application of engineering knowledge and resources to military purposes; and, second, with a view to setting forth, as far as practicable, the ways in which engineering is applied to military purposes and the means provided therefor.

Both military art and military engineering are progressive, and a considerable part of the latest and most detailed information published is available only in service journals of our own and foreign armies. This is particularly true of technical details of seacoast defense (including submarine mining), of field artillery, of military aviation, and the influence of these on military engineering. It is believed, however, that the fundamentals of each subject are well covered by the

references given in this list. While the list is long, the relative importance of the various works is indicated, and suitable comments on each are included, so that persons using the lists of references may be able to select those which particularly interest them.

The references under each subject are generally divided into two groups, the first containing the more essential references, and the second those suitable for persons desiring to inquire further into the subject.

Suggestions looking to improvements of the lists will be gladly received.

Note—The following abbreviations are used:

Supt. of Docs.—Superintendent of Documents, Government Printing Office, Washington, D. C.

Book Dept.—Book Department, Army Service Schools, Fort Leavenworth, Kans.

"A" MILITARY POLICY, CONDUCT OF WAR, AND MILITARY HISTORY.

Group I.

(1) Official Bulletin, Vol. I, No. 2, Office of the Chief of Staff, Washington, D. C.
(Especially pp. 21-39) Publisher: Army War College, Washington, D. C. Free.
(An official outline of the theory under which our forces are to be organized and administered.)

(2) Military Policy of the United States—Upton. May be obtained from Supt. of Docs.; paper, 50 cents; cloth, 65 cents.
(A most valuable and comprehensive review of this subject.)

(3) Field Service Regulations, 1914. May be obtained from Supt. of Docs.; 60 cents.
(A condensed official statement of principles, methods and details of military operations.)

(4) Elements of Strategy—Fiebeger. Publisher, U. S. Military Academy, West Point, N. Y. May be obtained from Book Dept.; 75 cents.
(A short outline, with historical illustrations.)

GROUP II.

(5) Conduct of War—Von der Goltz; translated by J. Dickman; Hudson Publishing Co., Kansas City, Mo. May be obtained from Book Dept.; $1.70.

(The standard work on this subject, covering generally the same ground as (4), but more abstractedly and elaborately.)

(6) On War—Clausewitz; translated by J. J. Graham; 3 vols.; K. Paul, Trench, Trubner & Co., 1908. May be obtained from Book Dept.; $6.60 (including postage and duty.)

(The greatest classic on the subject; a complete analysis of the phenomenon of war, and profound discussion of the mechanism thereof. Written early in the 19th Century, it is still the foundation of modern military theory.)

(6½) The Nation in Arms—Von der Goltz. May be obtained from Book Dept.; $2.50.

(An excellent modern work on war; less elaborate but more readable than Clausewitz.)

(7) American Campaigns—M. F. Steel; 2 vols.; Publishers: Byron S. Adams Publishing Co., Washington, D. C. May be obtained from Book Dept.; $4.50.

(In addition to careful historical surveys of all the campaigns from the Colonial Wars to the Spanish-American War, these lectures give extensive and valuable comments as to the military principles.)

(8) A study of Attacks on Fortified Harbors—Rodgers; Proceedings Nos. 111, 112 and 113, U. S. Naval Institute, Annapolis, Md.

(9) Lessons of the War with Spain—Mahan. Publishers: Little, Brown & Co., Boston, Mass. May be obtained from Book Dept.; $2.00.

(Of special importance, as showing the true relation between our coast defense and our navy).

(10) Reports of Military Observers on the Russo-Japanese War. Part III—J. E. Kuhn. May be obtained from Supt. of Docs.; 60 cents.

(In addition to an account of operations, this report contains valuable information as to fortification and siege work, organization and equipment.)

(11) Organization and Operation of the Lines of Communications in War—Furse, 1894. Publishers: Wm. Clowes & Sons., Ltd., London.

(An old but comprehensive survey of this subject, with much historical information.)

"B" PERMANENT FORTIFICATIONS.

Group I.

(The references given cover chiefly the principles and general features of this subject; the *details* are mostly printed in unavailable form, either in service journals or in confidential documents. References to some of the former can be furnished, if desired.)

(12) Report of National Coast Defense—(Taft) Board, 1906. May be obtained from Army War College, Washington, D. C. Free.

(The official project for harbor defenses of the United States. On account of progressive obsolescence of seacoast defenses, this project has been or is being, modified, but still sets forth clearly the fundamentals of its subject.)

Group II.

(13) Lectures on Seacoast Defense—Winslow. Publishers U. S. Engineer School, Washington Barracks, D. C. Price 50 cents.

(Much of these lectures relates to technical details, and a considerable part is now obsolete.)

(14) Permanent Fortifications—Fieberger, 1900; U. S. Military Academy, West Point, N. Y.; $1.00. May be obtained from Book Dept.

(While rather old, this work gives a simple presentation of the fundamentals on its subject, including an historical outline. A revised edition will soon be published.)

(15) Fortifications—C. S. Clarke; Dutton & Co., New York; $4.50. May be obtained from Book Dept.

(A treatise on the same lines as (14)).

(16) Principles of Land Defense—Thuillier, 1902; Longmans, Green & Co. May be obtained from Book Dept.; $3.83.

(A very valuable work, covering the principles of both field and permanent fortification.)

"C" ORGANIZATION, EQUIPMENT AND DUTIES OF ENGINEER TROOPS.

Group I.

(17) Field Service Regulations, 1914. (See "A" 3.)

(18) Tables of Organization, 1914. May be obtained from Supt. of Docs.; 25 cents.

(These tables represent—subject to modification and

within the limits of existing law—the approved policy of the War Department with regard to organization.)

(19) Official Bulletin, Office of the Chief of Staff, vol. I, No. 4 (Appendix 4). Use of Engineer Troops. Publisher: Army War College, Washington, D. C. Free.

(An official statement of the principles which should govern in the use of engineers, with practical suggestions.)

(20) Duties of Engineer Troops in a General Engagement of a Mixed Force—Burgess. Publishers: U. S. Engineer School, Washington Barracks, D. C.; 25 cents.

(Obsolete in some respects, particularly organization, but excellent in general scope.)

(21) General Orders No. 6, War Department, 1915. May be obtained from The Adjutant General, U. S. Army, Washington, D. C. Free.

(Prescribes the training of Engineer troops.)

Group II.

(22) Studies in Minor Tactics—Army Service Schools, 1915. May be obtained from Book Dept.; 50 cents.

(The principles of Minor Tactics are set forth by solution of a series of problems.)

(23) Technique of Modern Tactics—Bond & McDonough, 1914; Banta Publishing Co., Manasha, Wis. May be obtained from Book Dept.; $2.55.

(This work covers, in a very specific way, the principles of tactics for all arms, a general knowledge of which is essential for engineers.)

(24) Operation Orders—Von Kiesling; translation. May be obtained from Book Dept.; 50 cents.

(A lucid exposition, by use of assumed cases, of the operation of highly trained troops of all arms in various phases of battle.)

(25) Engineer Unit Accountability Manual. May be obtained from Supt. of Docs.; 5 cents.

(Official lists of standard equipment supplied to Engineer battalions and companies.)

(26) Organization of the Bridge Equipage of the U. S. Army, 1915 (Revised edition just going to press.)

(Includes description of equipage and regulations for ponton drill.)

(27) Officers' Manual—Moss; Banta Publishing Co., Menasha, Wis.; $2.50. May be obtained from Book Dept.
(Treats of routine duties of officers, customs of the service, army organization, etc.)

(28) Manual for Courts Martial. May be obtained from Supt. of Docs.; 50 cents.

"D" FIELD ENGINEERING.

(Military field engineering at the front differs from ordinary engineering work in the field, in being generally simpler, of a rough-and-ready character, and especially because of the limited equipment which can be taken along with the advance of an army, and because of the necessity of working in strict subordination to the military situation. In rear of the army, on the contrary, conditions are very similar to those governing ordinary engineering operations, and civilian organization is suitable, subject to directions by the higher military staff. Little attempt is made in works on military field engineering to treat of general engineering methods.)

(29) Field Fortifications—Fiebeger, 1913; John Wiley & Sons, New York. May be obtained from Book Dept.; $1.90.
(In addition to technical details, this work gives valuable historical illustrations of the principles of this subject.)

(30) Field Entrenchments, Spade work for Riflemen—John Murray, London. May be obtained from Book Dept.; 40 cents.
(A very up-to-date little work, especially on details.)

(31) Notes on Field Fortification—Army Field Engineer School. May be obtained from Book Dept.; 30 cents.

(32) Engineer Field Manual—Professional Papers No. 29, Corps of Engineers, U. S. Army, 3d edition, 1909, 500 pages. May be obtained from Supt. of Docs., $1.00.
(A very complete official pocketbook for Engineer officers in the field, containing much tabular and technical data, as well as brief outlines of principles and methods. The subjects covered are: Part I, Reconnaissance; Part II, Bridges; Part III, Roads; Part IV, Railroads; Part V, Field Fortification, and Part VI, Animal Transportation. A new revision of the manual is contemplated, but will not be ready within a year. The portion of the manual relating to Field Fortifications, being

somewhat obsolete, should be considered in connection with either (30) and (31) above. The portion relating to Railroads is largely superseded by (35) below.)

(33) Notes on Bridges and Bridging—Spalding. May be obtained from Book Dept.
(A small pamphlet on military bridging.)

(34) Military Topography for Mobile Forces—Sherrill, 2d edition; Banta Publishing Co., Menasha, Wis, 1911. May be obtained from Book Dept.; $2.25.
(Besides matter given in ordinary text-books on surveying, this work gives in detail the special methods of sketching developed in the army for rapid military mapping.)

(35) Military Railroads—Connor; Professional Papers No. 32, Corps of Engineers, U. S. Army. Supt. of Docs.; 50 cents.
(Intended to cover general administration of existing railroads for military purposes and the handling of railroads by military personnel in the advanced sections where railroads can not be operated by their regular civilian organizations, or where new railroads are required in the immediate vicinity of the Army. Revised edition soon to appear.)

(36) Notes on Military Explosives—Weaver; J. Wiley & Sons, New York; 1912. May be obtained from Book Dept.; $2.20.
(Elementary notes on this subject will be found in the Engineer Field Manual and other references cited. The work is more elaborate.)

"E" MISCELLANEOUS.

(37) Regulations for the Army of the United States; Supt. of Docs.; 50 cents.

(38) The "Volunteer Law," approved April 25, 1914; Bulletin No. 17, War Department, 1914. May be obtained from The Adjutant General, U. S. Army, Washington, D. C. Free.

(39) General Orders No. 54, War Department, 1914. May be obtained from The Adjutant General, U. S. Army, Washington, D. C. Free.
(Covers examination of candidates for commissions as officers of *volunteers*.)

(40) General Orders No. 50, War Department, 1915. May be obtained from The Adjutant General, U. S. Army, Washington, D. C. Free.

(Amends General Orders 54, 1914, as to examination of candidates for commissions in volunteer *engineers.*)

(41) Treatise on Military Law—Davis; J. Wiley & Sons, New York. May be obtained from Book Dept.; $5.30.

(42) Elements of Military Hygiene—Ashburne; new edition; Houghton, Mifflin & Co., Boston, 1915. May be obtained from Book Dept.; $1.30.

"F" PERIODICALS.

(43) Professional Memoirs, Corps of Engineers, U. S. A., and Engineer Department at Large; Bi-monthly (formerly quarterly); Washington Barracks, D. C., Engineer Press; per year, $3.00.

(44) The Royal Engineers' Journal—Royal Engineers' Institute, Chatham, England; Monthly; per year, $4.00. (American agents, E. Steiger & Co., 49 Murray St., New York).

(45) Journal of the Military Service Institution, Governors Island, New York. Bi-monthly; published by the Institution; per year, $3.00.

(46) Journal of the United States Artillery; Bi-monthly; Fort Monroe, Va.; Coast Artillery School press; per year, $2.75, including Index to Current Literature; without Index, $2.50.

(47) Journal of the United States Cavalry Association; published by the Association at Fort Leavenworth, Kans.; per year $2.50.

(48) Infantry Journal; Bi-monthly; published by the U. S. Infantry Association, Union Trust Building, Washington, D. C.; per year $3.00.

(49) Field Artillery Journal; quarterly; published by the U. S. Field Artillery Association, 601 *Star* Building, Washington, D. C.; per year $3.00.

APPENDIX II.

The following is a list of engineer property carried by each engineer company in the field. This is in addition to all camp and personal equipment, ordnance and quartermaster property, etc.

COMPANY ENGINEER PROPERTY.

EQUIPMENT.

Articles	Number.	Unit price.
Carpenter's equipment:[1]		
Augers, ship, handled, sets of 3	2	$3.02
Awls, scratch	2	.14
Axes, handled, 32-inch	2	.72
Bits—		
Auger, sets of 7	2	3.19
Expansion	2	1.60
Screw-driver	4	.13
Braces, ratchet	2	2.25
Chests, carpenter's	2	3.00
Chisels—		
Cold	2	.38
Framing, handled, sets of 3	2	2.75
Dividers, wing	2	.47
Drawknives	2	1.70
Files, saw, taper	12	.17
Hammers, claw	2	.45
Handles—		
Ax, 32-inch	2	.15
Chisel, framing, 6-inch	2	.10
Hammer, claw	2	.10
Hatchets	10	.63
Levels, carpenter's, 24-inch	2	2.63
Mallets, carpenter's	2	.25
Oilers, ½ pint	2	.41
Oilstones	2	.94
Planes, jack	2	.86
Pliers, side-cutting	2	.72
Plumb bobs, 6-ounce	2	.54
Rules, 2-foot, 4-fold	8	.26

[1] One-half to each company tool wagon.

Articles	Number.	Unit price.
Saws—		
Compass	2	1.00
Crosscut, hand	4	1.30
Rip, hand	2	1.30
Saw sets	2	1.10
Screw-drivers	2	.25
Squares—		
Steel, carpenter's	2	1.20
Try	2	.25
Tapes, metallic, 50-foot	2	2.30
T bevels	2	.25
Wrenches, monkey, 12-inch	2	.72
Demolition equipment:[1]		
Augers—		
Earth, handled	2	5.25
Ship, 1½-inch, handled	2	1.32
Bars—		
Pinch, large	2	.80
Wood, tamping	2	.25
Boxes—		
Cap	2	2.00
Match	2	.25
Chisels, cold	2	.38
Circuit detectors	2	5.00
Crimpers	2	.50
Drills—		
Single-bit, long	2	1.53
Single-bit, short	2	.60
Hammers, sledge, 8-pound	4	.80
Magneto exploders	2	14.85
Pick mattocks, E. D. pattern, "Intrenching," handled	4	.48
Shovels, E. D. pattern, "Intrenching".	8	.55
Reels, wire, firing	2	1.50
Spoons, miner's, long	2	1.00
Wire, firing, double lead No. 14..feet..	2000	.01
Drafting Equipment:[1]		
Boards, drawing, 23 by 31 inch, with trestles	2	3.15
Erasers, steel	2	.80
Erasing Shields	2	.12
Instruments, drawing, field sets	2	14.00
Lamps, acetylene	2	24.00
Map measures	2	2.20
Protractors, G. S., semicircular, 6-inch	2	2.15

[1] One-half to each company tool wagon.

Articles	Number.	Unit price.
Scales—		
Architect's, 12-inch, with sheaths.	2	1.50
Engineer's, 12-inch, with sheaths.	2	1.50
Triangles—		
30-60°, 10-inch	2	.80
45°, 8-inch	2	.80
T squares, 24-inch	2	6.23
Tubes, tin	6	1.10
Hectograph equipment:[1]		
Hectographs, clay, 20 by 24 inch	2	13.25
Levelers, hectograph	2	.25
Sponges	2	.25
Miscellaneous equipment:[1]		
Bags—		
Nail, 50-pound	4	.75
Nail, 100 pound	2	1.00
Buckets, galvanized iron	6	.42
Cans, galvanized iron, 5-gallon	2	5.50
Carborundum wheels	2	5.50
Handles—		
Auger, ship	2	.15
Hammer, sledge, 8-pound	2	.20
Hatchet, 16-inch	6	.15
Pick mattock, E. D. pattern, "Intrenching"	12	.15
Lanterns—		
Dark	6	1.00
Dietz	12	2.50
Manuals—		
Engineer field	24	1.00
Ponton	2	1.00
Marlinspikes	2	.12
Padlocks, brass	12	.85
Stamps, steel, sets	2	7.70
Stencils, sets	2	.70
Wagons, tool, company	2	300.00
Photographic equipment:[2]		
Blankets, rubber	2	2.00
Bucket, canvas	2	1.50
Bulbs, rubber	1	.25
Cameras, 3-A Kodak, complete with cases	1	21.95
Exposure meters	1	2.00
Film tanks, Kodak, 3½-inch	1	3.75

[1] One-half to each company tool wagon.
[2] All in one company tool wagon.

Articles	Number.	Unit price.
Graduates, 8-ounce	1	.40
Lamps, ruby	1	.77
Manuals, photographer's	1	.50
Printing frames, 5 by 7 inches	2	.45
Rods, stirring, hard rubber	2	.15
Shears, 8-inch	1	.90
Thermometers, photographic	1	.40
Towels, bath	4	.22
Trays, agate, nested, sets of 4	4	3.15
Tripods, metal, folding	1	1.95
Pioneer equipment:[1]		
Adzes, handled, 32-inch	4	1.35
Axes, handled, 36-inch	26	.72
Bars, pinch, large	2	.80
Blades, hacksaw, dozens	1	.40
Blocks—		
8-inch, double	2	3.22
8-inch, single	2	2.06
8-inch, snatch	2	5.25
8-inch, triple	2	5.66
Climbers, lineman's, pairs	2	3.38
Comealongs	4	1.38
Files, crosscut saw	6	.22
Hammers, sledge, 8-pound	4	.80
Handles—		
Adz, 32-inch	2	.15
Ax, 36-inch	6	.15
Pick, railroad, 36-inch	2	.15
Saw, crosscut, 1-man	2	.10
Saw, crosscut, 2-man	2	.10
Hatchets	6	.63
Knives, Gabion	18	.85
Machetes, with sheaths	36	1.60
Mauls, wood	4	1.50
Peevies, handled	4	1.70
Picks, railroad, handled	6	.55
Pick mattocks—		
E. D. pattern, "Intrenching," handled	30	.48
Large, handled	6	.60
Pliers, side-cutting	24	.72
Points, pike and hook	4	1.12
Posthole diggers	2	2.00

[1] One-half to each company tool wagon.

Articles	Number.	Unit price.
Rope, manila, 1 inch diameter, 250-foot coils	2	8.25
Saws—		
Crosscut, 1-man	2	1.13
Crosscut, 2-man	4	1.38
Hack	2	.50
Saw tools	2	1.10
Shovels—		
E. D. pattern, "Intrenching"	60	.55
Long-handled	12	.75
Tapes, metallic, 50-foot	4	2.30
Wedges, steel, 5-pound	4	1.30
Wrenches—		
Monkey, 18-inch	2	1.50
Stillson, 18-inch	2	3.00
Reconnaissance equipment:[1]		
Alidades	6	1.25
Barometers, aneriod, with cases	4	20.00
Boards, sketching	6	7.55
Chests, sketching outfit	6	6.60
Clinometers, service, with cases	14	8.90
Compasses—		
Box	4	2.65
Prismatic, with cases	4	9.55
Watch	12	1.55
Field glasses, with cases	2	19.00
Holders, timing pad	6	1.50
Odometers, with cases	2	10.50
Pace tallies	14	3.25
Pencil pockets	6	2.20
Protractors, rectangular	8	1.32
Sextants, pocket	2	36.00
Tripods, wood, folding	6	4.25
Pack No. 1: Equipment:		
Augers, ship, 7/16 inch, handled	2	.80
Awls, stitching	1	.07
Bags, nail, 10-pound	2	.25
Bars, pinch, small	1	.30
Bits—		
Auger, sets of 7	1	3.19
Screw driver	1	.13
Bags, carpenter	1	.25
Boxes, pack No. 1	2	6.00

[1] One-half to each company tool wagon.

Articles	Number.	Unit price.
Braces, ratchet	1	2.25
Chisels, framing, sets of 3	1	2.75
Files, flat, bastard, 12-inch	1	.16
Hammers—		
Claw	2	.45
Farrier's	1	.48
Sledge, 8-pound	1	.80
Hatchets	4	.63
Knife, shoeing	1	.38
Nippers, shoeing	1	.82
Pincers, shoeing	1	.77
Pliers, side-cutting	2	.72
Punch, revolving	1	1.32
Rasp, shoeing, 16-inch	1	.32
Rivet set	1	.45
Rolls, canvas, for tools	3	1.00
Saws, crosscut, hand, 20-inch	2	1.25
Squares, steel, carpenter's	1	1.20
Tapes, metallic, 50-foot	1	2.30
Wrenches, monkey, 12-inch	1	.72
Packs Nos. 2 and 3: Equipment:[1]		
Augers, ship, 1½-inch, handled	2	1.32
Bars, pinch, small	2	.30
Boxes—		
Cap	4	2.00
Match	4	.25
Packs Nos. 2 and 3	4	6.00
Buckets, canvas	2	1.50
Chisels, cold	2	.38
Crimpers	4	.50
Drills, single-bit, short	2	.60
Hammers, sledge, 8-pound	2	.80
Knives, clasp	4	.75
Pick mattocks, E. D. pattern, "Mining," handled	2	.55
Pliers, side-cutting	4	.72
Rolls, canvas, for tools	4	1.00
Shovels, E. D. pattern, "Mining"	2	.55
Spoons, miners', short	2	1.00
Pack No. 4: Equipment:		
Axes, handled, 36-inch	6	.72
Boxes, pack, No. 4	2	6.00

[1] Packs Nos. 2 and 3 are identical.

Articles	Number.	Unit price.
Pick mattocks, E. D. pattern, "Mining," handled	10	.55
Shovels, E. D. pattern, "Mining"	20	.55
Pack No. 5: Equipment:		
Blocks—		
6-inch, double	2	1.50
6-inch, single	2	.83
6-inch, snatch	2	3.50
Boxes, Pack No. 5	2	6.00
Hatchets	2	.63
Machetes, with sheaths	10	1.60
Rope, manila, ¾-inch diameter, 200-foot coils	2	4.08
Saws—		
Folding, with cases	2	5.00
Crosscut, hand, 20-inch	2	1.25

NOTE.

If the company is not provided with pack animals, the fact will be stated on the engineer return and the above equipment will be modified as follows:

Omit.

Equipment—Packs Nos. 1-5.

SUPPLIES KEPT ON HAND.[1]

Carpenter's supplies:[2]		
Chalk, carpenter's, pound	½	$0.20
Chalk lines, 40-foot	4	.08
Pencils, carpenter's, dozen	1	.42
Demolition supplies:[2]		
Caps, detonating	100	.01½
Explosive, pounds	200	.60
Fuse—		
Bickford, feet	200	.00½
Instantaneous, feet	200	.04½
Fuses, electric	200	.04
Matches, safety, boxes, dozen	1	.05
Tape, insulating, rolls	2	1.00
Twine, hemp, 2-ounce balls	2	.08

[1] The quantities of supplies indicated will be kept on hand at all times as far as possible, except those marked (*), which, being subject to deterioration in store, will ordinarily be kept on hand in quantities sufficient for immediate needs only, being increased to the full amounts prescribed when field service is anticipated. Supplies expended will be replaced by requisition as soon as possible.

[2] One-half to each company tool wagon.

Articles	Number.	Unit price.
Drafting supplies:[1]		
Books, note	6	.20
Carbide, in 10-pound cans, pounds	40	.11
Cloth, tracing, 30-inch, 24-yard rolls	2	7.00
Erasers—		
Rubber, pencil	4	.06
Rubber, ink	2	.05
Ink—		
Drawing, black, bottles	4	.19
Drawing, blue, bottles	2	.19
Drawing, carmine, bottles	2	.19
India, sticks	2	.60
Pads—		
Pencil-pointing, 1¼ by 4 inches	2	.08
Scratch, 6 by 9 inches	4	.07
Paper—		
Blotting, 3¾ by 9½ inches, dozen	2	.20
Drawing, 22 by 30 inches, gross	2	6.66
Pencils—		
Drawing, H	12	.08
Drawing, 3H	12	.08
Pens—		
Crow-quill, dozen, with holder, cards	2	.32
Mapping, dozen, with holder, cards	2	.32
Pins, cones	2	.08
Tacks, thumb, dozen	2	.36
Tape, adhesive, rolls	4	.02
Twine, hemp, 2-ounce balls	2	.08
Hectograph supplies:[1]		
Ink—		
Green, hectograph, bottles	2	.17
Red, hectograph, bottles	2	.17
Violet, hectograph, bottles	4	.17
Paper, book, 19 by 24 inches, quires	10	.27
Miscellaneous supplies:[1]		
Canvas, 10-ounce, yards	20	.40
Grease, axle, pounds	10	.15
Marline, pounds	36	.15
Nails—		
60d, wire spike, pounds	200	.02¾
30d, wire spike, pounds	100	.02¾
16d, wire, pounds	100	.02¾

[1] One-half to each company tool wagon.

Oil—		
Coal, gallons	10	.12
Machine, quarts	2	.10
Staples, pounds	20	.05
Screws, assorted, gross	6	.30
Wicks—		
Lantern, dark, dozen	1	.18
Lantern, Dietz, dozen	2	.18
Wire, B. & S. No. 16, pounds	50	.04
Photographic supplies:[2]		
Albums, film negative, 3¼ by 5½ inches	1	.77
Books, photographic, note	1	.40
Cheesecloth, white, yards	3	.05
Developer—		
Ideal, M. Q., boxes	8	.44
Pyro, tank, boxes	8	.35
*Films, Kodak, 3¼ by 5½ inches, rolls of 6 exposures	24	.31
Formaline, pounds	1	.30
Hypo acid, Kodak, in ¼-pound boxes, pounds	12	.32
Intensifier, tubes	1	.16
*Paper, developing, 4 by 6 inches, gross	1	1.35
*Paper, printing out, 3¼ by 5½ inches, gross	1	1.50
Photo clips, dozen	1	.20
Potassium bicarbonate, pounds	1	.20
Potassium bromide, tabloid, tubes	1	.08
Push pins, dozen	1	.08
Reducer, tubes	1	.22
Refills, for exposure meter, packages	1	.22
Twine, hemp, 2-ounce balls	1	.08
Wicks, ruby lantern, dozen	½	.35
Pioneer supplies:[1]		
Bolts—		
Drift, ¾-inch	80	.03
Drift, ½-inch	80	.03
Rope—		
Manila, ¾-inch diameter, 50-foot lashings	24	1.00
Manila, ½-inch diameter, 18-foot lashings	50	.18
Sandbags, with binders	500	.10
Tape, tracing, feet	3000	.00½

[1] One-half to each company tool wagon.
[2] All in one company tool wagon.

Articles	Number.	Unit price.
Reconnaissance supplies:[1]		
Books, note, field	32	.20
Celluloid, sheets	72	.10
Erasers, rubber, pencil	28	.06
Pads, timing	36	.20
Paper, sketching, sheets, gross	3	3.00
Pencils—		
Blue	28	.08
Drawing, H	84	.08
Green	28	.08
Red	28	.08
Protectors, pencil-point	28	.05
Tape, adhesive, rolls	12	.02
Pack No. 1, Supplies:		
Beeswax, ounces	2	.02
Bolts, drift, ½-inch	40	.03
Chalk, carpenter's, pounds	¼	.20
Chalk lines, 40-foot	2	.08
Nails—		
60d, wire spike, pounds	10	.02¾
16d, wire, pounds	10	.02¾
Horseshoe, pounds	3	.08
Needles, harness, papers	2	.06
Pencils, carpenter's, dozen	½	.42
Rivets, harness, assorted, pounds	1	.40
Shoes, mule, fitted	6	.12
Thread, harness, 2-ounce balls	1	.11
Packs Nos. 2 and 3, Supplies:[2]		
Caps, detonating	200	.01½
Cord, detonating, spools	8	2.92
Explosive, pounds	180	.82
Fuse, Bickford, feet	400	.00½
Fuse lighters, Bickford	120	.02
Matches, safety, boxes, dozen	2	.05
Rope, manila, ½-inch diameter, 18-foot lashings	4	.18
Twine, hemp, 2-ounce ball	2	.08
Unions, detonating cord	48	.02
Wire, copper, No. 30, ¼-pound spools	4	.37

[1] One-half to each company tool wagon.
[2] Packs Nos. 2 and 3 are identical.

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